MC PAMPELET

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**ENGINEERING DESIGN** HANDBOOK

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EXPLOSIVES SERIES PROPERTIES OF EXPLOSIVES OF MILITARY INTEREST

HEADQUARTERS, U.S. ARMY MATERIEL COMMAND

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#### PREFACE

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The Engineering Design Handbock Series of the Army Materiel Command is a coordinated series of handbocks containing basic information and fundamental data useful in the design and development of Army materiel and systems. The handbooks are authoritative reference books of prectical information and quantitative facts heipful in the design and development of Army materiel so that it will meet the tactical and technical needs of the Armed Forces.

AMCP 705-177, Properties of Explosive of Military Interest, is one of a series on Explosives. One hundred and ten explosive compounds or mixtures are listed herein, alpha-betically, with their properties, including composition variations. These explosives were selected because of their current or probable application to military use.

The tabulated data reflect the results of tests, and were inst compiled for publica-tion at Picatinny Arsenal, Dover, New Jersey, by H. R. Tomlinson, Jr. These data were later revised by Oliver E. Sheffield, also of Picatinny Arsenal. for the Engineering Hand-book Office of Duke University, prime contractor to the Army Matarial Command.

The Handbooks are readily available to all elements of AMC, including personnel and contractors having a need and/or requirement. The Army Materiel Command policy is to re-lease these Engineering Design Handbooks to ther DOD activities and their contractors and to other Government agencies in accordance with current Army Regulation 70-31, dated 9 September 1966. Procedures for acquiring these Handbooks follow:

a. Activities within ANC and other DOD agencies order direct on an official form from:

Commandin, Officer Letterkeniv Army Depot, ATTN: AM Chambersburg, Pennsylvania 17201 AMXLE-ATD

Contractors who have Department of Defense contracts should submit their ь. proper justification to the address requests through their contracting officer listed in par. a.

c. Government agencies other than  $D_{\rm eD}$  having need for the Handbooks may submit their requests directly to the address listed in par. a or to:

Commanding General U. S. Army Materiel Command ATTN: AMCAM-ABS Washington, D. C. 20315

Industries not having Government contracts (this includes colleges and d. Universities) must forward their requests to:

Commanding General U. S. Army Materiel Command ATTN: AMCRD-TV

Washington, D. C. 20315 All foreign requests must be submitted through the Washington, D. C.

ę. Embassy to:

Assistant Chief of Staff for Intelligence Foreign Liaison Office Department of the Army Washington, D. C. 20310

All requests, other than those originating within DOD, must be accompanied by a valid justification.

Comments and suggestions on this handbook are welcomed and should be addressed to Army Research Office-Durham, Box CM, Duke Station, Durham, North Carolina 27706.

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## ABBREVIATIONS AND SYMBOLS

approximately. This symbol is used before numbers.

Advisory Council on Scientific Research and Develop-

۸C ACS AISI Ann Ann chim phys AP APG ats Beil Ber BIOS GP2-HEC BM Bull Soc caim CA calc Cham Ket Eng Chim et Ind Comp read C P C R dec ΔE DRP E E Gazz chim ital GP HE HEAT Ind Eng Chem J Am Chem Soc Chem Ind J Chen Soc **Prank Inst** J Ind Explo-

sives Soc J prakt Chem

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ment, Great Britain. American Chemical Society. American ïron and Steel Institute. Liebig's Annalen der Chemie. Annales de chimie et de physique. armor-piercing. Aberdeen Proving Ground. atmosphere: atmospheric pressure. Beilstein Organische Chemie, 4th Edition. Berichte der Deutschen Chemischen Gesellschaft. British Intelligence Overseas Service or Objective Subcommittee, Group 2, Helstead Exploiting Center. Bureau of Mines, United States Department of Interior. Bulletin de la societé chimique de France. Chemical Abstracts. calculated. Chemical and Metallurgical Engineering. Chimie et Industrie. Comptes rendus hebdomadaires des geances de l'Academie des Sciences (Parie). centipoise. tomptes rendus hebiomadaires des seances de l'Academie des Sciences (Paris). decomposes. difference in heat (i.e., heat evolved) by decomposition. Deutsches Reichspatent. Deutsches Reichspatent. modulus of elesticity or "Young's modulus"; longitudinal stress/change in length; (force/area)/(elongation/ length); expressed in lb/inch<sup>2</sup>. same as Z, but expressed in dynes/cm<sup>2</sup>. Gazzetta Chimica Italiana. Gazzetta Chimica Italiana. general purpose. high explosive. high explosive antitank. Industrial & Engineering Chemistry. Journal of the American Chemical Society The Journal of the Society of Chemical Industry (London). Journal of the Chemical Society (London). Journal of the Franklin Institute. Journal of the Industrial Explosives Society (Japan). Journal für praktische Chemie. lead az'de Landolt-Bornstein Physikalish-Chewische Tabellen, 5th Edition (Berlin). molar. Monatshefte für Chemie (Wein). Mémorial des poudres et salpêtres (Paris). milligram.

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## ABBREVILTIONS AND SYMRGLS (cont'd)

sinimum. min #1 #/# milliliter. meters per second. molecular weight. Bureau of Ordnance (U. S. Savy) nitrocelluloge. MW NAVORD NC n<sup>D</sup>20 index of refraction, with D band of sodium as light source, at twenty degrees centigrade. Notional Defense Research Committee. NDRC National Fireworks Ordnance Corporation. WYOC nitroglycerin. U. S. Naval Ordnance Laboratory, White Oak, Silver HG. NOL Spring, Maryland. U. S. Naval Ordnance Test Station, China Lake, Calif. ROTS National Research Council. NRC oxygen balance. OB Ordnance Committee Minutes. Office of Scientific Research and Development OCH OSRD Picatinny Arsenal. Picatinny Arsenal Technical Report. PA PATR Phil Trans Philosophical Transactions of the Royal Society of London. Poggendorf's Annalen der Physik. Proceedings of the Boyal Society of London. Recueil des traveux chimiques des Pays-Bas. Pogg Ann Proc Roy Soc Rec trav chim relative humidity. Report of Investigation. RH RI SAE Society of Automotive Engineers. semi-armor-piercing. SAP solution. soi Spec std dev Specifications. 
 Spec
 Specifications.

 std dev
 standard deviation.

 TM
 Technical Hanual, Department of the Army.

 TM/TO
 joint publication, as a TM and as a Department of the Air Force Technical Order.

 Trans Farad Soc Transactions of the Fareday Society

 vacuum stability.

 Technical Charle
 Zeitschrift für angewandte Chemie. Zeitschrift für anorganische und allgemeine Chemie. Zeitschrift für das gesamte Schiess und Sprengstoff-wessen (Munchen). Z angew Chem Z anorg Chem Z ges Schiets-Sprengstoflw 2/820 atoms of oxyge per second.

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## PROPERTIES OF EXPLOSIVES OF MILITARY INTEREST

## INTRODUCTION

1. PREDENIMANTLY A REPORT OF STANDARD TESTS. No effort was made to cover all the existing literature, either open or classified security information, on say explosive. Nather, the main resource has been reports from facilities using standard of well-known test procedures.

2. ORIGIN. Compilation of data resulting in this handbook was undertaken by Picatinny Arsenal personnel who desired to provide a manual tabulating the characteristics of explosives, based on tests, with regard to current, and possible future, interest. The first resulting Picatinny Arsenal publication was dated 20 June 1949. Revision 1, PA Technical Report No. 1740, dated April 1950, with revisions, provides the data used herein.

3. SCFE. Tabulated data of tests on one hundred and ten explosive compounds or mixtures include sensitivity to friction, impact, heat; performance characteristics or effectiveness in weapons; physical and cherical properties; and method of preparation, synthesis or manufacture, with comments on h storical origin, and supplementary references.

. REFERENCE MOTATIONS AND SOURCES. The references, as to sources of data or for more details in methods of testing, have been listed, when available, at the and of each section devoted to a given emplosive compound, explosive mixture, or explosive ingredient. Where no reference is given, it can be assumed that these data represent typical values obtained by standard procedures. When available any reference should be consulted for more details in interpreting test data.

Also there are listed Picatinny Arsenal Technical Reports which contain "dditional information on the particular exclosive. These report numbers are given in ascending order, in columns corresponding to their terminal digits, and in accordance with the "Uniterm Index" prepared for Picatinny Arsenal by Documentation Incorporated under Contract DAI-36-034-501-ORD-(P)-42 (1955).

5. EXPLANATION OF TERMS AND METRODS OF TESTING. Data are tabulated herein on three form-type pages, in the following sequence of headings. Many of these terms are self-explanatory.

#### a. First tabular page.

- (1) Name of the explosive in each instance.
- (2) "Composition."
- (3) "Impact Sensitivity, 2 Kg Wt."
  - (a) Impact sensitivity test for solids. (a)\*

A sample (approximately 0.02 gram) of explosive is subjected to the action of a falling weight, usually 2 kilograms. A 20-milligram sample of explosive is always used in the Bureau of Mines (BM) apparatus when testing solid explosives. The veight of sample used in the Picatinny Arsenal (PA) apparatus is indicated in each case. The <u>impact test value</u> is the minimum

\*Reference publications (a through q), applying to this introduction, are listed at the end of the introduction.

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neight at which at least one of 10 trials results in <u>Optionic</u>. For the BN apparatus, the unit of height is the continuetr; for the PA apparatus, it is the inch. In the former, the apposive is held between two flat, parallel bardened (C  $G_{3,2}$  2) steel surfaces; in the latter case, it is placed in the depression of a small steel dis-cup, capped by a thin brass cover, in the center of which is placed a slotted-vented-cylindrical steel plug, slotted side down. In the BM apparatus, the impact impulse is transmitted to the sample by the upper flat surface, in the PA, by the vented plug. The main differences between the two tests are that the PA text (1) involves greater confinement, (2) distributes the translational impulse over a smaller area (due to the inclined sides of the dis-cup cavity), and (3) involves a frictical component 'against the inclined sides).

The test value obtained with the PA apparatus depends, to a marked degree, on the sample density. This value indicates the hazard to be expected on subjecting the particular sample to an impact blow, but is of value in assessing a material's inherent sensitivity only if the apparent density (charge weight) is recorded along with the impact test value. The values tabulated harein were obtained on material screened between 50 and 100 mesh, U. S. Standard Screens where single component explosives are involved, and through 50 mesh for the mixtures.

(b) Impact sensitivity test for liquids. (b)

The PI Impact Test for liquids is run in the same way as for solids. The die-cup is filled and the top of the liquid maniscus adjusted to coincide with the plane of the top rim of the die-cup. To date, this visual observation has been found adequate to assure that the liquid does not wot the die-cup rim after the brass cap has been set in place. Thus far the reproducibility of data obtained in this way indicate that variations in sample size obtained are not significant.

In the case of the EM apparatus, the procedure that was described for solids is used with the following variations:

1. The weight of explosive tested is 0.007-gm.

2. A disc of desiccated filter paper (Whatman No. 1) 9.5-millimeter diameter, is laid on each drop, on the anvil, and then the plunger is lowered on the sample absorbed in the filter paper.

(4) "Friction Pendulum Test." (c)

A 7.0-gm sample of explosive, 50-100 mesh, is exposed to the action of a steel, or fiber, shoe swinging as a pendulum at the end of a long steel rod. The behavior of the sample is described qualitatively to indicate its reaction to this experience, i.e., the most emergetic reaction is explosion, and in decreasing order of severity of reaction: snaps, cracks, and unaffected.

(5) "Rifle Bullet Impact Test." (d)

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Approximately 0.5-pound of explosive is loaded in the same manner as it is loaded for actual use: that is, cast, pressed, or liquid in a 3-inch pipe nipple (2-inch inside diameter, 1/10inch wall) closed on each end by a cap. The loaded item, in the standard test, contains a small air space which can, if desired, be filled by inserting a wax pluy. The loaded item is subjected to the impact of a caliber .30 bullet fired perpendicularly to the long axis of the pipe nipple, from a distance of 90 feet.

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## (6) "Explosion Temperature." (a)

A 0.02-gm sample (0.01-gm in the case of initiators) of explosive, loose loaded in a No. 8 blasting cap, is immersed for a short period in a <u>Wood s metal</u> bath. The temperature determined is that which produces explosion, ignition or decc position of the sample in 5 seconds, and the behavior of the sample is indicated by "Explodes" or "Ignites" or "Decomposes" placed beside the value. Where values were available for times other than 5 seconds, these have been included. For 0.1-second values, no cap was used, but the explosive was placed directly on <u>Wood's metal</u> bath, immediately after cleaning. The value 0.1 second is estimated, not determined, and represents an interval regarded as instantaneous to the observer's eye. Dashes indicate no action-

(7) "75°C International Heat Test." (a)

A 10-gm sample is heated for 48 hours at  $75^{\circ}$ C. The sample after this exposure is observed for signs of decomposition or volatility.

(8) "100°C Heat Test." (a)

A 0.6-gm sample is heated for two 48-hour periods at  $100^{\circ}$ C. It is also noted whether exposure at  $100^{\circ}$ C for 100 hours results in explosion.

(9) "Flammatility Index." (h)

The measure of the likelihood that there charge will catch fire when exposed to flames is the index of flammability. The test is made by bringing an oxyhydrogen flame to bear on the explosive. The maximum time of exposure which gives no ignition in 10 trials and the minimum exposure which gives ignition in each of 10 trials are determined. The index of flammability is 100 divided by the mean of the two times in seconds. The most flammable substances have high indices, e.g., 250.

#### (10) "Hygroscoricity."

A 5- to 10-gm sample is exposed for hygroscopicity under the stated conditions, until equilibrium is attained, or in cases where either the rate is extremely low, or very large amounts of water are picked up, for the stated time. The sample, if solid, is prepared by sieving through a 50 and on a 100 mesh screen.

(11) "Volatility."

A .3-gm sample is exposed for volatility under the stated conditions. The sample if solid is prepared by sieving through a 50 and on a 100 mesh sieve.

(12) "Molecular Weight."

The molecular weight (MN) of a mixture can be calculated from the equation

$$\frac{100}{\frac{8}{100} + \frac{1}{100} + \frac{1}{100} + \frac{1}{100}}$$

where a, b, c and z are the weight purcents of the components, and  $mv_1$ ,  $mv_2$ ,  $mv_3$  and  $mw_n$  their corresponding molecular weights.

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#### (13) "Oxygen Balance."

The caygen balance (OB) is calc lated from the empirical formula of a compound in percentage of caygen required for complete conversion of carbon to carbon dioxide (or carbon monomide) and hydregen to water. When metal is present the reactions are assumed to occur in the following there:

> Hetal + 0  $\longrightarrow$  Hetal Oxide C + E<sub>2</sub>O  $\longrightarrow$  CO + E<sub>2</sub> CO<sub>2</sub> + E<sub>2</sub>  $\longrightarrow$  CO + E<sub>2</sub>O 200 + O<sub>2</sub>  $\longrightarrow$  200<sub>2</sub>

Procedure for valculating unygen balance is to determine the number of gramatoms of oxygen which are excess or deficient for 100 grams of a compound. This number multiplied by the atomic weight of oxygen gives

the oxygen balance: 1600 (2X +  $\frac{Y}{2}$  - Z)

 $\div$  molecular weight of compound = cxygen balance to CO<sub>2</sub> and H<sub>2</sub>O, where X = atoms of "urbon. X = atoms of hydrogen, Z = atoms of oxygen. The cxygen balance of a mixture is equal to the sum of the percent composition times the cxygen balance for each component.

the carbon/hydrogen (C/E) ratio is calculated as follows:

Humber of C atoms  $(\frac{4}{5}C + \frac{4}{5}H) = C/H$  ratio

(14) "Density."

- (15) "Melting Point."
- (16) "Freesing Polat."
- (17) "Poiling Point."
- (18) "Refractive Index."
- (19) "Vacuum Stability Test." (a)

A 5.0-gm sample (1.0 gm for initiators), after having been carefully dried is heated for 40 hours, in vacuo at the desired temperature.

(20) "200 Gram Bomb Sand Test."

(a) Sand test for solids. (a)

A 0.4-gm sample of explosive, pressed at 3000 pounds per square inch into a No. 6 cmp, is initiated by lead azide, or mercury fulminate (or, if necessary, by lead azide and tetryl), in a sand test bomb containing 200 gm of "on 30 mesh" Ottawa sand. The amount of azide, or of tetryl, that must be used, to insure that the sample trushes the maximum net weight of sand, is designated as its <u>sensitivity to initiation</u> and the net weight of sand crushed, finer than

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30 mesh, is termed the send test value. The net weight of sand crushed is obtained by subtracting from the total the amount crushed by the initiator when shot alone.

#### (b) Sand test for liquide. (b)

The sand test for liquids is made in accordance with the procedure given for solids except that the following procedure for locaing the test samples is substituted:

Cut the closed end from a No. 6 blasting cap and load one end of the resulting cylinder with 0.20 gm of lead axide and 0.25 gm of tetryl, using a pressure of 3000 psi for consolidating each charge. With a pin, prick the powder train in one end of a piece of miner's black powder fuse 8 or 9 inches long. Crimp to the pricked end a loaded cylinder, taking care that the end of the fuse is held firmly against the charge in the cap. Crimp near the mouth of the cap so as to avoid squeezing the charge. Transfer a weighed portion of 0.400 gm of the test explosive to an aluminum cap, taking precautions when the explosive is liquid to insert the sample in such a manner that as little as possible laberes to the side walls of the cap, and when a solid material is being tested use material fine enough to pass through a No. 100 U. S. Standard Sieve. The caps used shall be of the following dimensions: length 2.00 inches, internal dismeter 0.248-inch, wall thickness 0.025-inch. Press solid explosives, after insertion into the aluminum cap, by means of hand pressure to an apparent density of approximately 1.2 gm per cubic centimeter. This was done by careting hand pressure on a wooden plunger until the plunger had entered the cap to a depth of 3.93 centimeters. Following are the dimensions of the interior of the cap: height 5.00 cm, area of cross section 0.312 square centimeters. Insert the cylinder containing the fuse and explosive charge of tetryl and lead axide into the aluminum cap containing the fuse and explosive charge of tetryl and lead axide into the aluminum cap containing the test explosive for the determination of sand crushed.

(21) "Sensitivity to Initiation."

This is <u>sensitivity to initiation</u> as described under the preceding heading. The minimum detonating charge, in greas, required to detonate the explosive sample, is given.

(22) "Ballistic Mortar, % TNT." (e)

The amount of sample under test which is necessary to raise the heavy ballistic mortar to the same height to which it is raised by 10 gm of trinitrotoluene (TNT) is determined. The sample is then rated, on a proportionate basis, as having a certain TNT value, i.e., as being a certain percent as effective as TNT in this respect. The formula is

## INT value = 10 x 100.

The ballistic mortar consists of a long compound supporting rod, at the end of which is supported a heavy short-nosed mortar. The mortar contains a chamber about 6 inches in diameter and 1 foot long. A projectile occupies about 7 inches of the chamber and the sample to be tested occupies a small portion of the remainder of the chamber. When the sample is detonated, the projectile is driven into a sand bank, and the mortar swings through an angle which is marked on paper by a pencil attached to the mortar. The angle thus indicates the height to which the pendulum is maised by the explosion, and this latter represents the energy measured by this test procedure.

#### (23) "Trauzl Test, % TET." (d)

A sample of the explosive to be tested (of the order of 10 gm) is exploded in a cavity, or borehole, 25-mm in diameter and 125-mm deep, in a lead block 200-mm in diameter and 200-mm in height. The borehole is made centrally in the up or face of each block, which is cast in a mold from desilverized lead of the best quality. Although these tests have been mode under a variety

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of conditions, where possible the data have been taken from or related to those of Reference f (Nacum). Here a No. 8 blasting cap was used for initiation of the sample contained in glass. The weight of sample used was adjusted to give, with the initiator, a total expansion of 250 to 300 cc, since within this range expansion and sample weight were linearly related under the conditions - Nacum's test. Thus expansions for equivalent weights were readily calculated, and the test alue expressed in percent of the expansion of an equivalent weight of TNT.

(24) "Plate Dent Test." (d)

Two methods were used for plate dent tests.

(a) Method A - Ine charge is contained in a copper tube, having an internal dismeter of 3/4-inch and 1/16-inch wall. This loaded tube is placed vertically on a square piece of cold-rolled steel plate, 5/8-inch thick; 4-inch and 3-1/4-inch square plate gave the same results. The steel plate 's in a horizontal position and rests in turn on a short length of heavy steel tubing 1-1/2 inches ID and 3 inches OD. The charge rests on the center of the plate and the centers of the charge, plate, and supporting tube are in the same line. A 20-gm charge of the explosive under test is boostered by a 5-gm pellet of tetryl, in turn initiated by a No. 8 detonator.

(b) Method B - A 1-5/8-inch diameter, 5-inch long uncased charge is fired on a 1-3/4-inch thick, 5-square inch cold-rolled steel plate, with one or more similar plates us backing. The charge is initiated with a No. 8 detonator and two 1-5/8-inch diameter, 30-gm tetryl boosters.

Plate dent test value, or relative brisance =  $\frac{\text{Sample Dent Depth}}{\text{Dent Depth for TNT at 1.61 gm/cc}} \times 200.$ 

#### (25) "Drivetion Rate." (g)

The detonation rates reported in the tables contained herein were determined principally by using the rotating drum camera, under the conditions stated, e.g., usually charges 1 inch in diameter, 20 inches long, wrapped in cellulose acetate sheet, and initiated by a system designed to produce high order stable detonation at the maximum rate under the particular conditions. A typical initiating system for this consisted of four tetryl pellets 0.395 inch in diameter, 0.75 inch long, pressed to 1.50 gm/cc, with a Corps of Engineers special blasting cap placed in a central hole in the end pellet.

b. Second tabular page.

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(1) "Booster Sensitivity Test." (p)

The booster sensitivity test procedure is a scaled up modification of the Bruceton method (unconfined charge). The source of the shock consists of two tetryl pellets, each 1.57 inches diameter by 1.60 inches high, of approximately 100 gm total weight. The initial shock is degraded through wax spacers of cast Acrawax B,  $1-5/\delta$  inches diameter. The test charges are 1-5/8 inches diameter by 5 inches long. The value given is the thickness of wax in inches at the 50% detonation point. The weight of tetryl pellet noted is the minimum which will produce detonation with the spacer indicated.

#### (2) "Heat of" (calorimetric tests). (i)

Heats of combustion and explosion are generally determined on samples weighing of the order of 1 to 2 gm, in standard calorimeter bombs such as the Parr or Emerson, approximately 400 cc = (for low loading density), or the Boas, approximately 45 cc (for high loading density). For

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heats of combustion the sample is burned under about 40 atmospheres of oxygen; for heats of explosion, nitrogen, or one atmosphere of air is used.

(3) "Specific Heat."

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- (4) "Burning Rate."
- (5) "Thermal Conductivity."
- (6) "Coefficient of Expansion."
- (7) "Hardness, Mohs' Scale."
- (8) "Young's Modulus."
- (9) "Compressive Starngth."
- (10) "Vapor Pressure."

-5

- (11) "Decomposition Equation."
- (12) "Armor Plate Impact Test." (j)
  - (a) 60-mm Mortar Projectile.

A modified 60-mm, M-9A2, mortar projectile is loaded with the explosive to be tested, drilled to the proper depth (about 1/2 inch), and a flat-based steel plug screwed into the projectile to give a smooth close-fit between the plug base and the charge. The part of the plug outside the projectile is rounded off in the form of a spherical section. The loaded projectile with fins attached is fired from a five foot length of 2-3/8 inches ID x 3-3/8 inches OD Shelby steel tubing. The igniter and propelling charge, consisting of an igniter for a 2.36-inch rocket (basooka), 5 gm of 4F bL ck power, and a quantity of shotgun propellant sufficient to give the desired velocity (read from a calibration chart) are conveniently loaded into the "gun" through a simple breach plug. The velocities are measured electronically, and the reaction, inart or affected, is determined by observation (e.g., whether or not flash occurs on impact). Within the range of flight stability of the projectile, 200-1100 ft/sec, the 50% point is located.

(b) 500-1b General Purpose Bombs.

(13) "Bomb Drop Test."

Bomb drops are made using bombs assembled in the conventional manner, as for service usage, but containing oither inert or simulated fuzes. The target is usually reinforced concrete.

c. Third tabular page.

(1) "Fragmentation Test." (1)

The weight of each empty projectile and weight of water displaced by the explosive charge is determined, and from this the specific gravity of the charge is calculated. All 3-inch and 90-mm projectiles are initiated by M20 Booster pellets, and those used with 3-inch HE. M42Al, Lot KC-5 and 90-mm HE, M71, Lot WC-91 projectiles are controlled in weight and height as follows:  $22.50 \pm 0.10$  gm, and 0.480 to 0.485 inch.

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The projectile assembled with fure, actuated by a Hasting Cap, Special, Type II (Spec  $\frac{1}{9}$ -20) placed directly on a lead of comparable diameter and booster, are placed in boxes constructed of half-inch pine. The 90-mm projectiles are frequented in boxes 21 x 10-1/2 x 10-1/2 inches and the 3-inch projectiles in boxes 15 x 9 x 9 inches outside dimensions. The box with projectile is placed on about 4 feet of sand in a sizel frequentation tub, the detorator wires are connected, and the box covered with approximately 4 feet more of saud. The projectile is fired and the sand run onto a gyrating 4-mean screen on which the frequents are recovered.

#### (2) "Fregment Velocity."

Charges 10-1/8 inches long and 2 inches in dismeter, containing a booster cavity, filled by a 72-gm tetryl pellet (1-3/8 inches diameter, 2 inches long, average density 1.594) are fired in a model projectile of Shelby seamless tubing, 2 inches ID, 3 inches OD, SAE 1020 steel, with a welded-on cold rolled steel base. The projectile is so fired in a chamber, connected to a corridor containing velocity stations, that a desired wedge of projectile casing fragments can be observed. The fragment velocities are determined by shadow photographs, using flash bulbs, and rotating drum cameras, each behind three slits. The drum cameras have a writing speed of 30 meters per second.

(3) "Blast (Relative to TNT)."

The blast pressures and impulses given were determined almost exclusively with tournaline gages, and the usual necessary specialized electrical circuits, shielded cc-axial cables, oscillographs, etc. In general, the data represent results of tests with large cased charges.

## (4) "Shaped Charge Effectiveness, THT = 103." (k, m)

Unconfined charges 2 inches in diameter and 6 inches long, boostered by a 10-gm pressed tetryl pellet, set in a 20-mm pellet (truncated come) of cast 60/40 cyclotol, are shot against 3-inch homogeneous armor plate at a 1-3/16 inches standoff. The cones used are commercial Pyre.. glass funnels, sealed off at the start of the stem, 2 inches in diameter, 0.110 to 0.125 inch well thickness.

Unconfined charges 1.63 inches in dismeter and 6 inches long are tested at a standoff of 1.63 inches against stacks of  $4 \times 4 \times 1$  inch mild steel plates. M9Al steel comes are used. Results are averages of 4 trials.

- (5) "Color."
- (6) "Principal Uses."
- (7) "Method of Loading."
- (8) "Loading Density."
- (9) "Storage."

8

Assumition and bulk explosives in storage represent varying degrees of hazard and compatibility. This has led to their being divided into a number of hazard classes and compatibility groups as indicated in subparagraphs (b) and (c) below.

- (a) Mathod: Wet or dry.
- (b) Bazard Class (Quantity-Distance).

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Assumition and bulk explosives are divided into quantity-distance classes, Class 1 through 12, according to the damage expected if they explode or ignite (Keference: Army Materiel Command Regulation, ANCR 385-100, <u>ANC Safety Nanual</u>, chapter 17). All standard explosives in bulk are included in four of these classes: Class 2, 2A, 9, and 12 (TM 9-1910/TO 11A-1-34).

#### (c) Corpetibility Group.

Explosives and assumition are grouped for compatibility with respect to the following factors:

- 1. Effects of explosion of the item.
- 2. Rate of deterioration.
- 3. Secutivity to initiation.
- 4. Type of packing.
- 5. Effects of fire involving the item.
- 6. Quantity of explosive per unit.
- (d) Emdation.

#### d. Miscellaneous entries.

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Where available and appropriate, the following or related data are given, in space at the bottom of the third form, or on plain pages.

- (1) Solubility.
- (2) Methods of manufacture.
- (3) Historics: information.
- (4) Bulk compressibility modulus. (9)

The direct experimental measurement of the dynamic bulk modulus of a solid is difficult, and few such measurements have been made. One apparatus has been developed at the Haval Ordnance Laboratory and is described in detail in Reference q. Bulk modulus (its reciprocal is the compressibility) is defined as the ratio of stress to strain when the stress is a pressure sphiled equally on all surfaces of the sample and the strain is the fesulting change in volume per unit volume.

· (5) Hydrolysis tests. (o)

The 200-hour hydrolysis test is conducted as follows: A 5-gm sample of the dry nitrocellulose is weighed accurately in a tare-weighed 250-ac Pyrex flask having a ground glass connection for a Pyrex condenser. Then 100 cc of distilled water is added to the nitrocellulose in the flask and the flask fitted to the condenser. The flask is placed in a steam bath in which the water is kept boiling constantly t; means of electric hotplates. At the end of 240 hours the amount of solid developed by the hydrolysis of the nitrocellulose is measured by an electromatic pH method.

(6) Sensitivity to initiatic, by electrostatic discharge. (n)

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The samples are tested under two amounts of confinement, designated as unconfined and confined. In the unconfined test, a sample of approximately 0.05 gm is dumped into a shallow depression in a steel block and flattened out with a spatula. In the confined tests (partly confined). The sample of approximately 0.05 gm is introduced into soft-glass tube ( $\sim 7$  mm ID x 18 um long) which fits over a metal pag. The volume of the space around the charge at zero gap is  $\sim 0.15$  cc; at a gap of 0.6 um; it is  $\sim 0.4$  cc. In addition to providing moderate confinement, this system also minimizes dispersion of the sample by the test spark, and reduces the effect of material bei; prepelled from the needle point by electrostatic field effect.

When a test is to be made, the needle point electrode is screwed up until the gap between electrodes is greater than the critical gap discharge at the test voltage. The sample is then placed in position, the high-voltage terminal of the charged condensor is switched to the point electrode by means of a mercury switch, and the electrode is screwed down until discharge occurs.

The spark energy (in joules), for zero probability of ignition, is determined.

(7) Destruction by chemical decomposition.

Burning is the preferred method of destroying exclosives. Initiating type explosives (in quantity) are usually destroyed by detonation with demolition blocks. Destruction of explosives by chemical decomposition can be effectively used where small laboratory quantities are involved. Procedures given are standard for only lead azide, mercury fulminate and nitroglycerin.

(8) Other information.

(9) References.

#### 6. REFERENCES CITED IN INTRODUCTION. 1

a. W. H. Rinkenbach and A. J. Clear, Scandard Laboratory Procedures for Sensitivity, Brisancy, and Stability of Explosives, PATR 50. 1401, 18 March 1944, Revised 28 February 1950.

b. W. R. Tomlinson, Jr. and A. J. Clear, <u>Development of Standard Tests -- Application of</u> the <u>Impact and Sand Tests to the Study of Nitroglyceriu and Other Liquid Explosives</u>, PATR No. 1738, 13 June 1949.

c. J. H. McIvor, Friction Pendulum, PA Testing Manual 7-1, 8 May 1950.

d. Departments of the Army and the Air Force Joint Technical Manual and Technical Order, TM 9-1910/TO 11A-1-34, <u>Military Explosives</u>, April 1955.

a. J. H. McIvor, Ballistic Mortar Test, PA Testing Manual 7-2, 8 May 1950.

f. Ph. Macum, Z ges Schless-Sprengetoffy, pp. 181, 229, 267 (27 June 1932).

g. G. J. Mueller, Equipment for the Study of the Detonation Process, PATR No. 1465, 4 July 1945.

h. MDRC Interim Report, <u>Preparation and Testing of Explosives</u>, Nos. PT-19 and PT-20, February-April 1944.

1. Linnie E. Newman, PA Chemical Laboratory Report Nos. 127815 and 134476, 11 January 1951.

j. Report AC-2983/Org Expl 179.

<sup>1</sup>For information regarding source of references, inquiries should be made to the Commander, U.S. Army Research Office--Durham, ATTN: CRDARD-EH, Box CM, Duke Station, Durham, North Carolina 27706.

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k. Bastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Section III, Variation of <u>Cavity Effect with Composition</u>, MIRC Contract W-572-ORD-5723.

1. J. H. sulvor, Frequentation Test Procedures, PA Testing Manual 5-1, 24 August 1950.

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n. F. W. Brown, D. H. Kusler, and F. C. Gibson, <u>Sensitivity of Explosives to Initiation</u> by Electrostatic Discharges, U. S. Department of Interior, Bureau of Mines, R. I. 3552, 1945.

o. D. D. Sager, Study of Acid Adsorption and Rydrolysis of Callulose Mitrate and Callulose Sulphate, PATR No. 174, 12 January 1932.

p. L. C. Smith and E. H. Eyster, <u>Physical Testing of Explosives</u>, Part III, Miscellanmous <u>Sensitivity Tests</u>, <u>Performance Tests</u>, CGRD Report No. 5746, 27 December 1945.

q. C. S. Sančler, An Acoustic Technique for Measuring the Effective Dynamic Bulk Modulus of Riasticity and Aspociated Loss Factor of Rubber and Plastics, NAVORD Report No. 1524, 1 September 1950.

W. S. Cramer, <u>Bulk Compressibility Data on Several Explosives</u>, MAVORD Report No. 4380, 15 September 1956.

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Amatol, 80/20

Composition: %		Molecular Weight:		92	
Anmonium Hitrate THT	80 20	Oxygen Balanes: COn % CO %	×.	+1 +11	
		Density: gm/cc Ct	het.	1.46	
(	14	Molting Point: "C			
C/H Ratio		Freezing Point: *C			
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	90	Bolling Point: "C			
Sample Wt 20 mg Picotinny Arsenal Apparatus, in. Sample Wr, mg		Refrective tades, nº nº nº			
Fristle's Pandzium Test: Steel Shoe Unaffe Fiber Shoe Unaffe		Vecuum Stebility Test: cc/40 Hrs, at 90°C			
Rifle Bullet Impact Test: 5 Trials		100°C	x	0.45	
%		120°C 135°C		0.95	
Explosions 0 Particls 0		150°C	×	6.8	:
Burned 0 Unoffected 100		200 Grem Bamb Send Test: Sand, gm		35.5	
fixplesion Temperature: *C Seconds, 0.1 (no cap. used) 1 5 Decomposes 280 10	<u>, , , , , , , , , , , , , , , , , , , </u>	Semistivity to Initiation: Minimum Detonating Ch Mercury Fulminata Lead Azide Tetryl	iorge, gm	0.20 0.07	
15 20		Ballistic Martur, % TNT:	(.)	130	
20		Trougi Test, % TNT:	(b)	123	
75°C Intornational Host Test: % Loss in 48 Hrs	0.06	Plate Dant Test: Method			
100°C Heat Test:		Condition		*	
% Loss, 1st 48 Hrs	0.03	Confined Density, gm/cc			
% Loss, 2nd 48 Hrs	0.05	Brisance, % TNT			
Explosion in 100 Hrs	None	Detenation Rate:		· · · · · · · · · · · · · · · · · · ·	
Firmmobility Index:		Confinement	None	None	
Hypressepicity: %		Condition	Cast	Cast	
30°C. 90% RH. 2 days	61	Charge Diameter, in. Density, gm/cc	1.0 1.46	1.0 1.50	
Veletility:	N11	Rate, meters/second	4500	5100	

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Energy

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#### Freg ntation Test: Shaped Charge Effectiveness, THT = 100: 90 mm HE, M71 Projectile, Lot WC-91: Glass Cones Steel Cones Density, gm/cc **Hole Volume** Charge Wt, Ib **Hole Depth** Total No. of Frage Colors Buff-yellow For TNT For Subject HE Principal Uses: Bombs, HE projectiles 3 inch HE, MC2A1 Projectile, Let KC-S: Density, gm/cc Churge Wt, Ib Total No. of Frage **Method of Looding:** Cast For TNT For Subject HE 1.46 Loading Density: gm/cc Fragment At 9 ft At 25% ft (f) 1900 1750 ant Valasity: ft/sec Storega: Density, gm/cc Method Dry Blast (Relative to TNT): Hazard Class (Quantity-Distance) Class 9 **Compatibility Group** Group I Ain Pacie Pressure Does not exude at 65°C Exudation Impulse Energy Booster Sensitivity Test: (a) Ale. Could Impulse Pressed 100 Condition Tetryl, gm Wax, in. for 50% Detonation Density, gm/cc for Water: 0.83 1.65 Peok Pressure Impulse Heat of: (d, e) Energy Combustion, cal/gm Explosion, cal/gm Gas Volume, cc/gm 1002\* 490\* 9**3**0\* Parts Pr Impulse

Amatol, 80/20

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\*Calculated from composition of mixture.

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Amatol, 60/40

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Competition:		Melecular Weight:	100			
Ammonium Nitrate INT	50 40	Oxygen Balence: CO2 % CO %	-18 + 2			
		Density: gm/cc Cast	1.60	-		
		Melting Point: *C	· · · ·			
C/H Rotio		Freezing Point: "C				
Import Sensitivity, 2 Kg Wt:		Boiling Point: "C				
Burrou of Mines Apparatus, cm Sample Wt 20 mg	95	Refrective Index, nº	· · · · · · · · · · · · · · · · · · ·			
Picatinny Arsenal Apparatus, in.	16 17	na				
Sample Wt, mg	1	n <sub>m</sub>				
Friction Pandulum Test:		Vocuum Stability Test:	*			
Steel Shoe		cc/40 Hrs, at				
Fiber Shoe		90°C				
Rifle Bullet Import Test: Trials		100°C				
<b>%</b>		135°C	-			
Explosions		150°C		-		
Partials						
Burned Unaffected		200 Grem Bomb Sond Test:	41.5	1		
	·····	Sand, gm				
Explanion Temporature: *C		Sonsitivity to Initiation:				
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, gm				
5 Decomposes 270		Mercury Fulminate Lead Azide	0.20	i		
10		Tetryl	0.06			
15						
20		Ballistic Mortor, % TNT: (8)	128			
75°C International Heat Test:	······	Treuzi Test, % TNT:				
% Loss in 48 Hrs		Piete Dent Test: Method				
100°C Heat Test:		Condition				
% Loss, 1st 48 Hrs		Confined				
% Loss, 2nd 48 Hrs		Density, gm/cc				
Explosion in 100 Hrs		Brisance, % TNT				
Fiemmebility Index:		Detenction Rate:	Fone			
		Confinemen. Condition	rone Casit			
Hygrascapicity: %		Charge Diometer, In.	1.0	İ		
		Density, gm/cc	1.50			
Veletility:	Nil	manual Multer		1		

Service Service

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regmentation Test:		Shaped Charge Effectiveness, TNT = 100:
90 mm HE, M71 Projectile, Let	WC-91:	Glass Cones Steel Cones
Density, gm/cc	1.49	Hole Volume
Chorge Wt, Ib	1.971	Hole Depth
Total No. of Fragments:		Color: Buttowellow
For TNT	703	Cover: Buff-yellow
For Subject HE	583	Principel Uses: Bombs, HE projectiles
3 inch HE, M42A1 Projectile, Let	KC-5:	Boulds, AE projectiles
Density, gm/cc	1.57	
Charge Wt, Ib	0.827	
Totel No. of Frequents:		
For TNT	514	Method of Looding: Cast
For Subject HE	408	
		Looding Density: gm/cc 160
regment Velocity: ft/sec At 9 ft At 25½ ft		Storoge:
Density, gm/cc		Method Dry
iert (Relative to TNT): Air:		Hazard Class (Quantity-Distance) Class 9 Compatibility Group Group I
Peak Pressure	95	
Impulse	85	Exusion Does not exude at 65°C
Energy	84	
Air, Confined:		Heat of: (d, e)
Impulse		Combustion, cal/gm 1658*
Ale da Miran		Explosion, cal/gm 633*
Under Weter: Peak Pressure		Gar Volume, cc/gm 380*
Impulse		
Energy		
Underground:		
Peak Pressure		
Peak Pressure		
Peak Pressure Imputse		
Peak Pressure Imputse		

## Amatol, 60/40

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AHCP 706 177

Amotol, 50/50

Composition:		Malatular Weight:		118		
70		Guygen Balance:				
Annonium Mitrate	50	CO, %		-27		
	50	CO %		<u>- 3</u>		
		Density: gm/cc ()	ast	1.54		
		Molting Point: *C		2		
C/H Rotio		Freezing Point: *C				
Impost Sensibility, 2 Kg Wit:	· ·	Bolling Point: *C				
Bureau of Mines Apparatus, che Sample Wt 20 mg	95	Refrective lades, no				
Picetinny Arsenal Apparatus, in.	16					
Sample Wt, mg	27	n <u>o</u>				
Feletien Pendulum Test:		Vocuum Stubility Test:				
Stael Shoe Uni	ffected	cc/40 Hrs, at				
Fiber Shoe Uni	ffected	90°C				
			:	:0 <b>.2</b>		
Rille Bullet Import Test: Trials		120°C		1.0		
Explosions 0		135°C				
Porticis 0		150°C				
Burned O		200 Green Bornh Sand Taur:				
Unoffected 100		Sand, gm		42.5		
Explosion Temperature: *C		Sensitivity to Initiation:				
Seconds, 0.1 (no ccp used)		Minimum Detonating Ch	orge, gm			
1		Mercury Fulminate				
5 Decomports 265		Lead Azide		0.20		
10		Tetryi		0.05		
15		Ballistic Marter, % TNT:	(.)	124		
20		Trougl Test, % ThiT:	(*)	164		
75 °C International Heat Test:		Plate Deat Test:				
96 Loss in 48 Hrs		Method		В		
180°C Heat Test:		Condition		Cast		
Start Loss, 1st 48 His		Confined		No		
•		Density, gm/cc		1.55		
96 Loss, 2nd 48 Hrs Evolution in 100 Mar		Brisance, % TNT		52		
Explosion in 100 Hrs						
Flemmehillity Index:		Detenation Rate:	M			
· · · · · · · · · · · · · · · · · · ·		Confinement	None Cast	None Cast		
Nygrescopicity: %	Nil	Condition				
		Charge Diameter, in.	1.0	1.0		
Velatility:		Density, gm/cc	1.55	1.55		
		Rate, meters/second	6430	6230		

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	Amet	tol, 50/50 AMCP 706-177
Programation Test:	<u> </u>	Shaped Charge Effectiveness, TMT = 100:
90 mm KE, MY1 Projectile, L	at WC-91:	Glass Corres Steel Corres (g)
Density, gm/cc	1.55	Hole Volume 53
Charge Wt, Ib	2.053	Hole Depth 69
Total No. of Progmants:		Color: Buff-ye)lov
For TNT	703	Comus Brit-Astron
For Subject HE	630	Principal Vess: Bombs, HE projectiles
3 inch HE, MGA1 Projectile,		
Density, gm/cc	1.54	
Charge Wr, ib	0.819	
Total No. of Fragmants:	•	Method of Looding: Cast <
For TNT	514	· · · · · · · · · · · · · · · · · · ·
For Subject HE	385	Leading Remains: gm/cc. 1.59
Fragment Velesity: ft/sec	h- <b>21</b> 44, 474-974, 274-274, 274-274, 274-274, 274-274, 274-274, 274-274, 274-274, 274-274, 274-274, 274-274, 274-	Leading Density: gn/cc 1-59
At 9 ft At 25% ft		Sturnge:
Density, gm/cc		-
		Method Dry
Blast (Relative to TNT):		Hozord Class (Quantity-Distance) Class 9
Ain		Compatibility Group Geoup I
Peak Pressure	<b>9</b> ī	
Impulse	87	Exudation Does not exude at 65°C
Energy		
Air, Cenfined:		Booster Sensitivity Test: (a)
impulse		Condition Cast Tetryl, gr 100
·		Wax, in. for 50% Detonation 0.60
Under Weter: Pook Pressure		Density, gm/cc 1.55
Impulse		Heat of: (d. e) Combustion, cal/gm 1990
Energy	93	Explosion, cal/gr. 703*
ar rev <b>2</b> 7	~	Gat Volume, cc/gm 855* *Calculated from composition of mixture.
Underground: Peak Pressure	104	
Impulse	104	$\frac{\text{Specific Heat: cal/gm/}^{\circ}C}{\text{Temp, } 20^{\circ} \text{ to } 80^{\circ}C} \qquad (i)$
Energy	104 104	Temp, 20° to 80°C 0.363 Bomh Drop Test:
- markh	70-1	T7, 2000-1b Semi-Armor-Piercing Bomb vs Concrete:
		Max Safe Drop, ft. 4000-5000

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#### AMCP 706-177

## Amatols 80/20, 60/10, 50/50

## Compatibility with Merals:

Exy - Metals unaffected are sinc, iron, tin, brass, brass tin plated, brass MRC costed, brass shellar costed, nickel aluminum, steel, steel plated with nickel, sinc or tin, stainless steel, Parkerized steel, and steel costed with acid-proof black paint. Metals slightly affected are copper, bronze, lead and copper plated steel.

#### Preparation:

In preparing another the proper granulation of argonium mitrate is required if the excisum density of the cest anatol is desired. The annother mitrate should be dried so as to contain not more than 0.25% moisture. It should be heated to about 90°C before being added to the appropriate weight of molten TNT contained in a melting vessel equipped with an agitator. Continue mixing to insure uniformity and load by pouring into shall or bombs.

#### Origin:

Developed by the British during world War I in order to conserve TNT.

## References: 2

(a) L. C. Smith and E. H. Evster, <u>Physical Testing of Explosives</u>, Part III, Miscellaneous <u>Sensitivity Tests</u>, <u>Performance Tests</u>, OSRD Report 5746, 27 December 1945.

(b) Report AC-17/Phys Ex 1.

(c) D. P. McLougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSR<sup>h</sup> Report No. 5746, 27 December 1945.

(3) Committee of Div 2 and 8, HDRC, Report on HBX and Tritonal, OSEB Report No. 5406, 31 July 1945.

(e) Philip C. Keenan and Dorothy Pipes, Table of Military High Explosives, Second Revision, MAVORD Report No. 87-46, 26 July 1946.

(f) R. W. Drake, <u>Pragment Velocity and Panel Penetration of Several Explosives in Simulated</u> Shells, OSRD Report No. 5622, 2 January 1946.

(g) Eastern Laboratory, du Port, <u>Investigation of Cavity Effect</u>, Final Report, 18 September 1943, NDRC Convract W-672-ORD-5723.

(h) Also see the following Picatinny Arsenal Technical Reports on Amatols:

<u>0</u>	1	2	3	<u>4</u>	2	<u>6</u>	<u>7</u>	8	2
240 350 630 950 1300 1530	681 731 901 1051 1311 1451 1651	132 182 1302 1352 1372 1372	743 1173 1373 1323 1493 1763	364 694 734 874 1344	65 425 695 715 735 1145 1225 1345 1885	266 556 666 986 1376 1446 1636 1796	1207 1457 1777 1827 2167	548 638 838 1098 1148 1388 1568 1838	549 799 929 1129 1219 1369 1559

(i) TM 9-1910/TO 11A-1-34, Military Explosives, April 1955.

<sup>2</sup>See footnote 1, page 10.

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Composition (	Melicedae Weight: 102	
Acmonium Nitrate 22 ISAL 67 Alumianon 11	Onygen Baisace: CO, %	
	Density gm/cc Oct 1.65	
	Melting Politic*C	1915
C/H Rstio	Freedore Points C	
im, act Venuit: ity, 2 Kg W1: Bureau of Mines Apparatus, cm 91	Bailing Pelat: C	
Some with the population of the second secon	Refroctive Index, ng	
Fri-sion Pandetum Vest: Step: Shoe	Veryam Stability Text cc/40 Hrs, at 90°C	
	100°C	

Fiber Shoe	cc/40 Hrs, ot 90°C
Rifle Builet Isspect Test: Trials % Explosions Partials	- 100°C 4.4. 120°C 4.4. 135°C 135°C 150°C
Burnod Unoffected	300 Grem Ramb Sand Test: Sond, gm h7.8
Explosion Temperature: *C Seconds, 0.1 (no cop used) 1 5 Decomposes 265 10	Seasiblyity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate 0.20 Lead Azide Tetryl
15 20	Beilistic Morter, % TNT: (a) 122
	Treuxi Test, % TNT:
75°C International Heat Test: % Loss in 48 Hrs	Plate Dant Tesi: Method
100°C Heet Test:           % Loss, 1st 48 Hrs         0.00           % Loss, 2nd 48 Hrs         0.10           Explusion in 100 Hrs         None	Condition Confined Density, gm/cc Brisance, % TNT
Flammebility Index:	- Detonution Rote: Confinement Condition
Velativity:	Charge Diameter, in. - Density, gm/cc Rate, meters/second

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## AHCP 706-177

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Fregmentution Test:	Shaped Charge Bifectiveness, TNT = 100:
90 mm 101, M71 Projectile, Let WG-91; Density, gm/cc Charge Wt, to	Glass Cones Steel Cones Hole Volume Hole Depth
Total No. of Progmants: For TNT	Color:
For Subject HE	
3 Inch HE, M42A1 Projectile, Lat KC-5:	Principal Uses: Projectile filler
<b>_</b>	1.65
	655 Method of Looding: Cast
FOR SUBJECT FIE	Looding Density: gm/cc 1.65
Fragmant Valacty: ft/sec	
At 25% ft Density, gm/cc	Storege: Method Dry
Biest (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9
Air: Peok Fressure	Compatibility Group
Impulso Energy	Exudation
Air, Confined: Impulse	Origin: Castable mixture developed in United States
Under Weber: Peak Pressure	during World War I. References:
Impulse	(a) W. R. Tomlinson, Jr., Physical and Ex-
En rgy	plosive Properties of Military Explosives, PATR No. 1372, 29 November 1943.
Underground: Peak Presture Impulse	(b) Also see the following Picstinny Ar- senal Technical Reports on Anmonals: 1108, 1286, 1292, 1308 and 1783.
Energy	
Preparation:	
Procedure same as described un except aluminum is added to the a trate-TNT molten mixture under sg til uniformity in composition is Loading is accomplished by pourin appropriate projectile.	importune hl-

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Amoniva Mitrate

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Composition:		Molucular Weight: (B <sub>1</sub> 3	2 <sup>0</sup> 3)	80
ж X 35		Oxygen Belence: COx %		+80
<b>E</b> 5	JEL JO .	<b>CO %</b>		+80
0 60	<b>4</b>	Beneity: gm/cc Cryst	<b>al</b>	1.73
		Moking Point: *C		170
C/H Ratio		Freezing Point: *C		
Bureau of Mines Apparotus, cm	100+	Boiling Point: "C		
Sample Wt 20 mg Picatinny Arsenal Apparatus, in Sample Wt, mg		Rafrezitire Juden, ng ng ng		•
Fristian Pandulum Test:		Vecues Stability Test:		
	mffected	cc/40 Hrs, at		
Fiber Shoe Ut	mifected	90°C		0.3
R/No Bullet Impact Test: Trials		120°C		0.3
<b>%</b>		135°C		
Explosions 0 Portiols 0		150°C		0.3
Burned 0		200 Grass Bamb Sand Test	 1	
Unoffected 100		Sand, gm	• .	H1
Explosion Temperature: *C	;	Sensitivity to Initiation:		
Seconds, 0.1 (no cap used)		Minimum Detonating C	har <b>ge, gm</b>	
) 5 Ignites 44	65	Mercury Fulminote		
10		Leod Azide		0.20 0.25
15		Tetryi		V·27
<b>20</b>		Ballistic Morter, % TNT:	(a)	56
75°C International Heat Test: (a		Trouzi Toot, % TNT:		
% Loss in 48 Hrs	0.0	Plate Deat Test: Method		
100°C Heat Test:		Condition		
% Loss, 1st 48 Hrs	0.74	Confined		
% Loss, 2nd 48 Hrs	0.13	Density, gm/cc Brizance, 94 TNT		
Explosion in 100 Hrs	None	Brisance, % TNT		
Flemmebility Index:		Detenation Rate: Confinement	(b) Nore	Steana
		Condition	None Solid	Strong Liquid
Hygrescepicity: %	Extreme	Charge Diameter, in.	1.25	4.5
30°C, 90% RH		Density, gm/cc	0.9	1.4
Veletility:	s at 210°C	Rate, meters/second	1000	2500

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Beesler Sensitivity Test: Candition	Decomposition Equation: (1) Oxygen, etome/sec 1013.8 (b) 12.3
Tetryi, gm.	(Z/sec) Heat, kilocolorie/mole 40.5 38.3
Wax, in. for 50% Detanation	Heat, kilocolorie/mole 40.5 38.3 (AH, kcol/mol)
Wax, gm	Temperature Range, *C 243-261 217-267
Density, gm/cc	Phase Idguid
Next of: Combustion, cal/gm 346	Armor Pisto Impost Test:
Explasion, cel/gm 346	
	60 mm Moster Projectile:
	50% Inert, Velocity, ft/sec
	Aluminum Fineness
Fusion, col/gm 18.23	500-16 General Purpose Bombe:
Speaklik: Heat: col/gm/°C (e)	Plate Thickness, inches
-150 0.189 0 0.397	
-100 0.330 50 0.41% -50 0.364 100 0.428	
-50 0.364 100 0.428	1%
	11/2
······································	
Burning Rate:	
cm/29C	Bamb Drop Test:
Thermal Conductivity: cal/sec/cm/*C 2.9-3.9 x 10 <sup>-4</sup>	T7, 2000-15 Yemi-Armer-Plencing Semb vs Concrete;
Coefficient of Expension:	Max Safe Drop, ft
Linear, %/*C	500-lb General Purpose Bomb vs Custorete:
Volume, %/°C	Height, ft
· · · · · · · · · · · · · · · · · · ·	Triols
Hordness, Mohs' Scole:	Unaffected
	Low Order
Young's Modulus:	High Order
E', dynes/cm <sup>2</sup>	
E, Ib/inch <sup>a</sup>	1060-Ib General Parpese Bomb v. Concrete:
Density, gm/cc	
	Height, ft
Compressive Strength: Ib/inch*	Trials
	Unaffected
Vapor Pressure: (g)	Low Order
*C mm Mercury	High Order
188 3.25	
205 7.45	
216 11.55	
223 15.80 234 \$1:8	

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Pregmentation Test:	Shaped Charge Rifestikausis, TMT = 100:
90 mm HE, M71 Projectile, Lat WC-91:	Glass Conves Steel Corres
Density, gm/cc	Hole Volume
Charge Wt, Ib	Holo Depth
Total No. of Progmants:	Color: Colorless
For TNT	
For Subject HE	Principal Uses: Explosive ingredient of
3 inch HE, MAZA1 Projectile, Let KC-5:	mixtures used in bombs or large
Density, gm/cc	caliber projectiles
Charge Wt, Ib	
Total No. of Fragments:	Mahed of Looing: Pressed or cast depending
For TNT For Schlash ME	on composition of mixture
For Subject HE	Looding Density: gm/cc Variable
Fregment Velecity: ft/sec	
At 9 ft At 25½ ft	Storege:
Density, gm/cc	
	Method Dry
Best (Relative to TNT):	Hazard Class (Quantity-Distance) Class 12
Ain	Compatibility Group Group D
Peak Pressure	
Impulse	Exudation None
Energy	
Air, Canfined:	Effect of Temperature on Impact Sensitivity (Chemically pure grade): (b)
Impulse	
Mar day Balance	Temp. PA Impact Test <u>C</u> 2 Kg Wt, inches
Under Weter: Peak Pressure	
Impulse	25 31 75 28
Energy	100 27
	150 27 175 12
Underground: Peak Pressure	
impulse	Compatibility with Matals: (a)
Energy	In the presence of moisture, ammonium
	nitrate reacts with copper, iron steel, brass, lead and cadmium.
	Entropy: (g)
	cal/mol at 25°C 36.0
	l

Ammonium Mitrate

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#### AHCP 706-177

## Ammonium Mitrate

Solubility of emcalum nitrate, grame in 100 grame (\$) of: (e)

	ter	Alo	obol	Acet	lc Acid		Mitric	Acid	Pyz	idine
ဗ်ဗဗင်ဗီ ၀ <mark>၊</mark> ၀	¥119972180	388 <sup>0</sup> °	2.5 5 7.5 10.5	°c 15.5 27.0 80.9 101.0 120.0	5.8 200 200 200 200 200 200 200 200 200 20	°C 25 30 75	45.1 73.0 106 201	<u>Acia</u> <u>Acia</u> <u>30.0</u> 21.7 20.8 31.6	Mo.	<b>≯</b> ∼∞≂≈

#### Preparation:

Associate and evaporation of the solution. The product which is very pure is dried in a graining kettle.

#### Origin:

First prepared by Glauber in 1659 and first used as an explosive ingredient in 1867 when a Swedish patent was granted to Chlsson and Morrbin for a composite dynamite.

#### Destruction by Chemical Decomposition:

Assonium nitrate is decomposed by strong alkalies with the liberation of assonia, and by sulfuric acid with the formation of assonium sulfate and nitric acid.

#### References: 3

(a) Departments of the Army and the Air Force TM 9-1910/TO 11a-1-34, Military Explosives, April 1955.

(b) P. F. Macy, T. D. Dudderar, E. F. Reese and L. H. Eriksen, <u>Investigation of Sensitivity</u> of Fertilizer Grade Annonium Mitrate to Explosion, PATR No. 1658, 11 July 1947.

(c) D. P. HecDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, Part III - Miscellaneous <u>Sensitivity Tests</u>; <u>Performance Tests</u>, OSRD Report No. 5746, 27 December 1945.

(e) International Critical Tables, McGraw-Hill Book Co., N. Y., Land-Bornst.

G. D. Clift and B. T. Federoff, <u>A Manual for Explosives Laboratories</u>, Vol. II, Lefax Society, Inc., Philadelphia, 1943.

(f) R. J. Pinkelstein and G. Gamow, <u>Theory of the Detonation Process</u>, NAVORD Report No. 90-46, 20 April 1947.

(g) George Feick, The Dissociation Pressure and Free Energy of Formation of Ammonium Mitrate, Arthur D. Little, Inc., J Am Chem Soc, <u>76</u>, 5858-60 (1954).

(h) M. A. Cook and M. Taylor Abegg," Isothermal Decomposition of Explosives", University of Utah, Ind Eng. Chem., June 1956, pp. 1090 to 1095.

<sup>3</sup>See footnote 1, page 10

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 /www.cnium Mitrate								AMCP 706-177	
(1) Alec	see the	following	Picatinny	Arsenal	Technical	Reports	on Anno	nium Mit	rate:
e Q.	1	2	3	<u>4</u>	٤	<u>6</u>	I	<u>8</u>	2
 240 350 630 1290 1720	681 731 1351 1941 1511 1391 1431	162 1302 1662	2183 1 1	094 214 234 304	695 1145 1225 1455 1655 1 1675 1 1725	596 666 676 946 106 696	907 1117 1947 2167	548 638 938 1008 1038	799 1369 1409

## AMCP 706-177

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#### onium Perchlorste

Competition:	Meleculer Weight: (GIRANOA) 127.5
10. 30.4 11.9	CO % +27. 3 CO % +27. 3
TEL CLO	Density: gm/cc 1.95
	Melting Point: *C
0 54.5 C/H Ratio	Frequing Point: "C
Impact Semilibility, 2 Kg Wtr	Belling Pelnt: *C
Bureau of Mines Apparatus, cm 67 Sample Wt 20 mg Picatinny Arsensi Apparatus, in. 24 Sample Wt, mg 24	Refrective lades, ng ng ng
Fristian Pundulum Test: Steel Shoc Banps Fiber Shoe Unaffected	Vuccuum Stability Test; cc/40 Hrs, at 90°C
Rifle Bullet Impact Teets Trials %	100°C 120°C 135°C
Portials Burned Unaffected	150°C         0.32           290 Grem Bomb Sand Test:         5and, gris           Sand, gris         6.0
Explosion Temperature: C Seconds, 0.1 (no cop used) 1 5 435 10 15	Sessitivity to Initiatian: Minimum Detonating Charge, gm Minimum Fulminate Lead Azide 0-20 Tetryi 0-25
20 20 20 20 20 20 20 20 20 20 20 20 20 2	Ballistie Marton, & THT:
	Truest Test, % TH":
75°C International Heat Test: % Loss in 48 Hrs	Plate Dont Test: Mathod
160°C Heat Yest:           % Loss, 1st 48 Hrs         0.02           % Locs, 2nd 48 Hrs         0.00           Suplasion in 100 Hrs         Bone	Condition Cunfined Density, gm/cc Brisance, % TNT
Flaxmability Index:	Detenation Rate: Confinement
Hygrescopicity: %	Condition Charge Diameter, in.
Yeletility:	Density, gm/cc Rate, meters/second

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Asmonium P	erchlorate ARCP 706-177
Progimentation Tests	Sheped Charge Effectiveness, THT = 198:
90 mie Mil, M71 Hogenila, Las WC-91:	Gless Cones Stasi Cones
Cancer, gen/cr	Hole Volume Hole Depth
Telei Vie / Josephinete: For TNT	Golar Colorless
For Subject HE 3 Inch HE, MIZAI Projectile, Let (C-3:	Principal Uses: Explosive ingredient of mixtures used in pyrotochnics and as projectile filler
Junchy, galies and the state of	
Total No. of Pregmants For TNT For Subject FE	Method of Looding: Pressed or cast depending on composition of mixture
	Loading Density: gm/ct Variable
ngment Velselly: ft/sec. At 9 ft	
Ar 25% R	Storeget 1
Density, gm/cc	Mathics Dry Con
last (Balative to TNT):	Hozord Class (Quantity Disurice) Class 9
	Compatibility Group
Peak Pressure Imputee Energy	Exudatic None
Air, Coolingit	Solubility in Water gm/100 cc saturated solution;
	0 <sup>0</sup> C 12
Valler Weler: Peak Prosturg	2)°C 20 50°C 39
Imputs	200°C
Energy	Preparations
Undergroand: Pook Pressure Inipulse	The perchlorates are prepared by the action of the acid on a suitable bash; by the ther- mal decomposition of certain chlorates; and by the electrolysis of chlorates (see origin).
Energy	Heat of:
	Formation, cal/gm 665

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## Assonius Perchlorate

## Origin: (c)

2. Mitscherlich first prepared, in 1832, crystals of associum perchlorate from barium perchlorate and associum sulfate (Pogg Ann 25, 300). T. Schlosing treated a hot solution of setium perchlorate with associum chloride, and on cooling, crystals of associum perchlorate were obtained (Comp rend, 73, 1259, [1971]). U. Alvisi treated a mixture of 76 perts of anzonium nitrate with 213 parts of sodium perchlorate, and obtained a crop of small crystals of runsmium perchlorate which were purified by recrystallisation from hot water (German Patent, 103,993, 1896). A. hiolati mixed megnesium or calcium perchlorate with emacuium chloride and crystals of associum perchlorate deposited from the solution of very soluble megnesium or calcium chloride (German Patent, 112, 682, 1899).

## Beferences: 4

(a) W. R. Tumlinson, Jr., <u>Fhysical and Explosive Properties of Military Explosives</u>, PAR No. 1372, 29 November 1943.

(b) T. L. Davis, The Chemistry of Powder and Explosives, John Wiley and Sons, Inc., New York, 19-3-

(c) J. W. Mellor, <u>A Comprehensive Treatise on Inorganic and Theoretical Chemistry</u>, Vol. II, Longarmus, Green and Co., London, 1922, p. 396.

(d) Also see the following Picatinny Arsenal Technical Reports on Annoniva Perchlorate:

0	1	C.C. 3	4	2	<u>6</u>	2	
100	<u>521</u>	843 1783	354 604 854	1095 1725 2205	1726	1049 1969	•

<sup>4</sup>See footnote 1, page 10.

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Composition: %	Molecular Weight:	125
Barium nitrate 67	Oxygen Belence: CO <sub>2</sub> % CO %	-3
TNT 33	Density: gm/cc Cast	+13
	Melting Point: °C	
C/Hi Ratio	Freezing Point: *C	
Impoct Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 35	Boiling Point: °C	
Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 11 Sample Wt, mg 24	Refractive Index, n <sub>20</sub> n <sub>20</sub> n <sub>20</sub>	
Friction Pondulum Test:	Vecuum Stebility Test:	
Steel Shoe Fiber Shoe	cc/40 Hrs, at 90°C	
Rifle Bullet Impoct Test: Trials	100°C 120°C	•
後 Explosions	135°C	1
Partials	150°C	
Burned Unoffected	200 Grem Bomb Sand Test: Sand, gm	26.8
Explosion Temperature: °C Seccids, 01 (no cap used)	Sensitivity to Initiation:  Ainimum Detonating Charge, g	m
I 5 Ignites 385	Mercury Fulminate Leod Azide	0.20
10	Tetryl	0.10
15 20	Sallistic Mortar, % TNT:	
	Trauzi Test, % TNT:	· · · · · · · · · · · · · · · · · · ·
75 °C International Haat Test: % Loss in 48 Hrs	Plote Demi Test: (a) Method	73/27 B
103°C Heat Test:	Condition	Cast
% Loss, 1st 48 Hrs	Confined	No
% Loss, 2nd 46 Hrs	Density, gn/cc Bricance & TNT	2.52
Explosion in 100 Hrs	Brisance, % TNT	<i>6</i> 1
Flammability Index:	Confinement	
Нудгозсорісіну: % 30 <sup>0</sup> С, 90% №	Condition Charge Diameter, in:	
Volatility:	Density. gm/cc Rate, meters/second	

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#### AXCP 706-177 Baratol wr Sa selfigity Test: southien to Ohygen, drame, sac (Z/sec) Condition Qeet. Setzyl, gm 100 Heat, kilocalorie/r (AH, kcal/mol) Work in. for 50% Defonation 0.32 , <sup>i</sup> Wax, gm Temperature Rong • Density, gm/cc 2.55 Philes . Neut of: Compution, cal/grn Armue Plain Is 54 t Test ÷ Explanion, cal/gm 9 mm Maitur Zer Scilles \$5% mert, Valucity, ft/sec 60 m Gas Volume, delam Formation, col/gm Aluminum Finances 2.8 (4) Fusion, coi/gm 75/25 Barstol nal Pr ic Heat: cal/gm/\*C (8) 75/25 Baratol Sp <u>60</u> °c Phote Thickness inches -75 0 25 50 0.152 0.147 0.160 0.229 0.280 0.213 0.201 0.171 75 85 90 100 1 114 -11/2 Z a start 1% g Rote: م. م بر از b Drop Tinit: 🤇 45 2 The colysac/cm/\*C 37, 2000-16 Semi-ScorePis VS CARE 1 Max Safe Drop, ft Linear, %7°C Confficie 500 h 8 qi Porp ercin: دي: در ي ٢. Ķ Volume %/\*C 45 Height, ft 2.2 Trigls es, Mohr' Scale; Harde Unafficied Low Order ng's Madu Ye hes: High Order E', dynes/cm\* . E, b/inch<sup>2</sup> 1006-Ib Gancrel I Density, gm/cc Height, ft Cas tive It-math: Ib/inch Frisk 49.1 Unoffected Voper Ransure: Low Order mm Mercury High Order

	Baratol AMCP 706-177
Fregmentation Test:	Shaped Charge Effectiveness, TNT = 100:
50 mai INE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth
Total No. of Fragments: For TNT For Subject HE 3 inch HE, M42A1 Projectile, Let KG-5: Density, gm/cc	Color: Principal Uses: Bomb filler
Charge Wt, Ib <b>Tatul No. of Fragmonts:</b> For TNT For Subject HE	Method of Leading: Cast
Fragment Valueity: ft/sec At 9 ft At 25½ ft Density, gm/cc	Sterege: Method Dry
Blast (Roletive to TP(T): Air: Peak Pressure Impulse Energy	Hazard Class (Quantity-Distance) Class 9 Compatibility Group Group I Exudation
Air, Confined: Impulse Under Weter: Peak Pressure Impulse Energy	<u>Preparation:</u> The appropriate weight of barium nitrate heated to about 90°C is added to molton TNT contained in a melting vessel equipped with an agitator. Continue mixing until uniform, and load by pouring at the lowest practical temperature.
Underground: Peak Pressure Impulse Energy	Origin: Raratol, an explosive containing barium nitrate and TNT, the proportions varied to suit the required purposes, was developed during World War I.

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Baratol

### References: 5

(a) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(b) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, <u>Part III - Miscellaneous</u> <u>Sensitivity Tests; Performance Tests</u>, OSRD Report No. 5746, 27 December 1945.

(c) Also see the following Picatinny Arsenal Technical Reports on Baratol:

<u>o</u>	3	6	8	
2010 2160	1783 2233	2226	2138	

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(d) C. Lenchitz, W. Beach and R. Valicky, Enthalpy Changes, Heat of Fusion and Specific Heat of Basic Explorives, PATR No. 2504, January 1959.

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<sup>5</sup>See footnote 1, page 10.

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Comp % Malecular Weight: 111 ution Co. ygen Bele CO. % CO % Barium nitrate 50 -24 - 7 TNT 35 Density: gm/cc 2.32 Aluminum 15 Melting Point: \*C C/H Ratio Freezing Point: "C Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg Builing Point: \*C 30 Refrective Index, nm 15 ng 22 n,o Friction Pendulum Test: Vec m Stability Test: Steel Shoe cc/40 Hrs, at 90°C Fiber Shoe 100°C Rifle Bullet Impoct Test: Trials 120°C % 135°C Explosions 150°C Partials Burned 200 Grew Bamb Sand Test: Soud, gm Unaffected 39.8 **Explosion Temperature:** ۰C Sensitivity to Initiation: Minimum Deconating Charge, gm Seconds, 0.1 (no cap used) Mercury Fulntingte 1 5 Ignites 345 Lead Azide 0.20 10 0.10 Tetryl 15 Ballistic Morter, % TNT: (a) 96 20 Treuzi Test, % TNT: 75°C International Heat Test: Plate Dent Test: % Loss in 48 Hrs Method Condition 100°C Heat Test: Confined % Loss, 1st 48 Hrs Density, gm/cc % Loss, 2nd 48 Hrs Brisance, % TNT Explasion in 100 Hrs (b) **Detonation Rate:** Flammability Index: lione Confinement Condition Cast Hygroscopicity: % Charge Diometer, in. 1.0 2.32 Density, gm/cc Valatility: Rate, meters/second 5450

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Fragmentation Test:	Shaped Charge Effectivanese, TNT = 100:
90 mm HE, M71 Projectile, Let WC-91:	Glass Cones Steel Cones
Density, gm/cc	Hole Volume
Charge Wt, ib	Hole Depth
Total No. of Progmants:	Color:
For TNT	
For Subject, HE	Principal Uses: Bomb filler
3 Inch HE, M42A1 Projectile, Let KC-S:	
Density, gm/cc	
Charge Wt, Ib	
Total No. of Fragments:	Method of Londing: Cast
For TNT	
For Subject HE	Louding Density: gm/cc 232
Fregme & Velecity: ft/sec	
At 9 ft At 25½ ft	Storoge:
Density, gm/cc	
	Method Dry
Blast (Relative to THT):	Hozord Closs (Quantity-Distance) Class 9
Air:	Compatibility Group Group I
Peak Pressure	
Impulse	Exudation
Energy	
Air, Confined:	Preparation:
Impulse	Procedure same as described under Baratol
	except aluminum is added to the barium ni-
Under Weter: Peak Pressure	trate-TNT molton mixture under agitation until uniformity in comparison is obtained.
Impulse	, and i uniformity in comparison is obtained.
Energy	Booster Sensitivity Test: (c)
	Condition Cast
Underground:	Tetryl, gm 100
Poak Pressure	Wax, in. for 50% Detonation 0.86 Density, gm/cc 2.32
Impulse	
Energy	Heat of:
	Combistion, cal/gm 2099
	Explosion, csl/gm 1135
	Gas Volume, cc/gu 410

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Baronal

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### References: 6

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(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosivie, Part III - Miscellaneous</u> <u>Sensitivity Tests; Performance Tests</u>, OSRD Report No. 5746, 27 December 1945.

(b) G. ... Messerly, The Bate of Detonation of Various Explosive Components, OSRD Report No. 1219, 22 February 1943.

M. D. Burwits, The Nate of Detonation of Various Compounds and Mixtures, OSRD Report No. 5611, 15 January 1945.

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) Arthur D. Little Report, Study of Pure Explosive Compounds, Part III, Correlation of Composition of Mixture with Performance, Contract No. DA-19-020-ORD-12, 1 May 1950.

(e) S. J. Lowell, <u>Propagation of Detonation in Long and Marrow Columns of Explosives</u>, PATR No. 2138, February 1955.

<sup>6</sup>See footnote 1, page 10.

### AMCP 706-177

### Black Powder

Composition:	Molecular Weight:	84
% Potassium nitrata 74.0	Caygen Belence: CO <sub>2</sub> % CO %	-22 - 2
Sulfur 10.4	Density: gm/cc	Variable
Charcoal 15.6	Malting Point: "C	
C/H Ratio	Freezing Point: "C	· ·
Impact Sensitivity, 2 Kg Wt:	Boiling Point: "C	
Bureau of Mines Apparatus, cm 32 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 16 Sample Wt, mg 16	Refrective Index, n <sup>D</sup> <sub>20</sub> n <sup>D</sup> <sub>20</sub>	
Friction Pandrium Test: Steel Silve Snaps Fiber Shos Unaffected	Vecuum Stubility Test: cc/40 Hrs, at 90°C	
Rifle Bullet Import Test: Trials % Explosions		0.5 0.9
Portiols Burned Unaffected	200 Grem Bomb Sead Test: Sand, gm	8
Explacion Temperature:         °C           Seconds, 0.1 (no cap used)         510           i         490           5         Ignites           10         356	Sensitivity to Initiation: Minimum Detonating Charge, gr Mercury Fulminate L'ad Azide Sensitive to igniting fuse	
15 20	Ballistic Mortar, % TNT:	50
	Trouzi Test, % TNT: (a)	10
75°C International Heat Test: % Loss in 48 Hrs 0.31	Plate Dant Test: Method	
t60°C Heat Test: % Lots, 1st 48 Hrs % Lots, 2nd 48 Hrs Exclosion in 100 Hrs	Condition Confined Density, gm/cc Brisonce, % TNT	
Planmability Index:	Detonetion Rate: Confinement	
Hygrescepicity: % 25°C, 75% RH 0.75 30°C, 90% RH 1.91 30°C, 90% RH 2.51	Condition Charge Diameter, in.	
Veletility:	Density, gm/cc	1.6

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Black Powder

AMCP 706-177

Fregmentation Test:		Sheped Charge Effectivenese, TNT == 100:		
90 mm HE, M71 Projectile, Let WC-91:		Glass Cones St	et Cones	
Density, gm/cc		Hole Volume		
Charge Wt, Ib		Hole Depth		
Total No. of Fragmants:	· .	Color: BL	•ck	
For TNT For Subject HE				
3 inch HE, M42A1 Projectile, Let KC-4:		Principal Uses: 1. Igniter po 2. Time rings		
Density, gm/cc				
Charge Wt, Ib				
Total No. of Fragments:		Mathod of Looding: 1. Loose		
For TNT		2. Presse	a	
For Subject HE		Loading Density: gm/cc	psi x 10 <sup>3</sup>	
Fragment Velocity: ft/soc		-25 50 60 65 1.74 1.84 1.86 1.87	70 75 1.88 1.89	
At 9 ft At 25½ ft		1.14 1.04 1.00 1.07 Storuge:	1.00 1.09	
Density, gm/cc		Method	Dry	
Bloot (Relative to TNT):		Hazard Class (Quantity-Distance	) Class 9	
Ain		Compatibility Group	Group O	
Peak Pressure			Ward	
Impulse		Exudation	None	
Energy			· · · · · · · · · · · · · · · · · · ·	
Air, Confined:		100 <sup>°C</sup> Vacuum Stability Test cc gas/40 hrs:	,	
Impulse		Initial Value	- 0.5	
-		After 2 hours at 65°C	0.8	
Under Water: Peak Pressure		After 2 Lours at 65°C, 75	% RH 1.40	
impulse		Sensitivity to Electrostati		
Energy		Discharge, Joules:	- (b)	
		Unconfined Confined	>12.5	
Underground: Peak Pressure		Compatibility with Metals:		
impulse		Dry - Compatible with al	1 metals when	
Energy		moisture content i		
Initiating Efficiency:		Wet - Attacks all common stainless steel.	metals except	
Grams Required to Initiate		Heat of:		
Igniter Comp K-31	2.0	Explosion, cal/gm	684	
Igniter Comp K-29	2.3	Gas Volume, cc/gm	271	

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#### Black Powder

#### Preparation:

Willow or alder charcoal, flour of sulphur and 2-3% of water are placed in a tuabling barrel and mixed for a short period (about 1/2 hour). The mixture is transferred to a "wheel mill" and crystalline potassium mitrate containing 3-4% moisture is added and the mixture is in orporated for several hours. During the incorporation period the mixture is kept damp (2-3% moisture) by adding water at intervals. The mill cake is then pressed at 6000 psi between aluminum plates. The pressed cakes are broken up between rubber or wood rolls. The material is screened and the various particle sizes are separated as desired. The screened material is then transferred to canvas trays and dried in hot air ovens at  $60^{\circ}$ C. If it is desired to glaze the black powder, the material before drying is polished by rotation in a tumbling barrel to give it a smooth surface. It is next screened to remove the dust. The smooth particles are then placed in a wooden barrel and rotated with graphite. The material is again screened to remove the excess graphite, and dried. Naterial finer than #40 U. S. Sieve is not graphited.

#### WARNING

The batches of black powder must be of sufficient size to cover the bed of the "wheel mill." If the wheels run off on the bare bed, explosions usually result.

#### Origin:

The exact date of the discovery of black powder is unknown. Historians attribute its discovery to the Chinese, Hindus or Arabs. The Greeks used it during the 7th Century. Marcus Graecus in the 9th Century and Roger Bacon in the 13th Century described compositions similar to the present powder. Beginning with the 16th Century, the composition of black powder containing potassium nitrate, charcoal and sulfur has versined unchanged with respect to the proportionality (75/15/10) of the ingredients.

#### Destruction by Chemical Decomposition:

Black powder can be desensitized by leaching with water to dissolve the potassium nitrate. The washings must be disposed of separately because the residue of sulfur and charcoal is combustible but not explosive.

#### References: 7

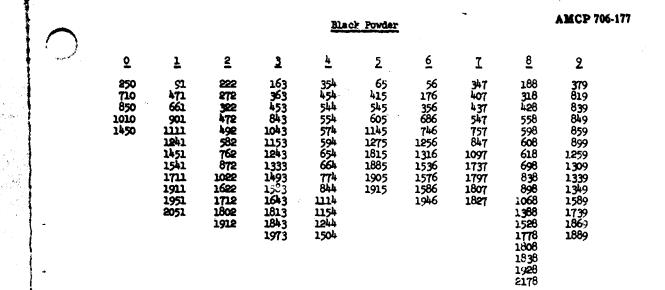
RH

(a) Fh. Naoum, <u>Nitroglycerine and Nitroglycerine Explosives</u>, Baltimore, 1928.

(b) F. W. Brown, D. H. Kusler and F. C. Gibson, Sensitivity of Explosives to Initiation by Electrostatic Discharges, U. S. Department of the Interior, Bureau of Mines RI 3852, 1946.

(c) Also see the following Picatinny Arsenal Technical Reports on Black Powder:

See footnote 1, page 10.



### AMCP 706-177

### 1,2,4-Butanetriol Trinitrate (BITN) Liquid

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Composition:		Molecular Weight: (C4H7N309)	241
с 19.9 н 2.9 н <sub>2</sub> с-ою <sub>2</sub>		Caygen Belence: CO. % CO %	-17 10
H2C			
N 17.5 7 HC-ONO <sub>2</sub>		Density: gm/cc Liquid	1.52
0 59.7 H <sub>2</sub> C-ONO2		Melting Point: °C	
C/H Ratio 0.13		Freezing Point: °C	
impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	58	Bailing Point: °C	
Sample Wt 20 mg		Refrective Index, no	1.4738
Picatinny Arsenal Apparatus, in. Sample Wt, mg	<u>&lt;1</u>	n <mark>o</mark>	
		n <u></u>	
Friction Pendulum Test:		Vocuum Stability Test:	
Steel Shoe		cc/40 Hrs, ut	
Fiber Shoe		90°C	0.03
Rifie Builet Imp. : Tent: Trials		100°C	2.33
. %		120°C 135°C	
Explosions		155 C	
Partials			
Burnzd	•	200 Gram Bomb Send Test:	
Unoffected		Sand, gm	48.6
Explosion Tomperature: °C		Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, gm	
5 Decomposes 230		Mercury Fulminote	
10			0.20
15		Tetry!	0.10
20		Ballistic Morter, % TNT:	
		Treuzi Test, % TNT:	
75°C International Heat Tost: % Loss in 48 Hrs		Plate Dent Test: Method	
100 C Heat Test:		Condition	
% Loss, 1st 48 Hrs	1.5	Confined	
% Loss, 2nd 48 rins	1.2	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TNT	
		Detenation Rate:	
Flammability Index:		Confinement	
Hygroscopicity: % (a)		Condition	
100°F, 95% RH, 24 hrs	0.14	Charge Diameter, in	
Veletility:		Density, gm/cc	
fo <sup>o</sup> C, mg/cm <sup>2</sup> /hr	46	Rate, meters/second	

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#### 1,2,4-Butanetrio) Triultrate (BTIN) Ligid

AMCP 706-177

regmentation Test:	Shapud Charge Effectiveness, TNT == 100:
90 cam HE, M71 Projectile, Lot WC-91:	Glass Cones Steel Cones
Density, gm/cc	Hale Volume
Charge Wt, Ib	Hole Depth
Tatul No. of Fragments:	Color: Yellow oil
For TNT	Terrow on
For Subject HE	Principal Uses: Explosive plesticizer for
3 inch HE, M42A1 Projectile, Let K&S-	nitrocellalose
Density, gm/cc	
Charge Wt, Ib	
Total No. of Fragments:	Method of Louding:
For TNT For Subject HE	······································
For Subject AL	Looding Density: gm/cc 1.52
regment Velocity: ft/sec	)
At 9 ft At 25½ ft	Storage:
Density, gm/cc	
	/Aethod
last (Relative to TNT):	Hazard Class (Quantity-Distance)
Air:	Compatibility Group
Peak Pressure	
<sup>t</sup> mpulse	Exudation
Energy	
Air, Confined:	Solublity in Mater, (a) gm/100 gm, et:
impulse	
	20 C 0.04 F0-C 0.15
Under Water: Peak Pressure	
Impulse	Solubilit of Water in, (a) gm/100 gm: 0.04
Energy	
	Solubility, gm/100 gm.
Vaderground:	<u>e· 25°C, ic:</u>
Peak Pressure	Ether Alcohol
impulse	2:1 Ether: Alcohol
Energy	hestone
	$\frac{V(c) \circ c(t),  \text{settingstree:}}{(c)}$
Hes. of: (a)	
Hest of: S (ε) Commuticut mal/gm Close Ext stion, cal/gm 10.7	10 A + 7 - 20

### AMCP 706-177

#### 1,2,4-Butanctriol Trinitrate (BTIN) Liquid

#### Preparation (Laboratory Procedure):

To a cooled mixture of 73.8 gm of 100% nitric acid,  $\frac{16.2}{9}$  gms of 106.2% sulfuric acid and 60.0 gm of 96.1% sulfuric acid, 30 gms of the original (or redistilled) 1,2,4-butanetriol was added dropwise with agitation for a period of thirty minutes. The temperature of the reaction mixture was kept at 0°-5°C. When the egitation was completed, stirring was continued for one and one-half hours. The mixture was poured into ice water, and the resulting oil suspension was extracted with three 100 milliliter portions of 6ther. The combined ether extracts were washed with water, then with a 5% sodium bicarbonate solution and finally with water. The neutralised extract was dried in a wacurm desiccator over anhydrous calcium chloride until the material was brought to constant weight.

#### Origin:

1,2,4-butanetriel was first synthesized by Wagner and Ginsberg in 1894 by oxidizing allyl carbinol with potassium perconganate under mild conditions (Ber 27, 2437). Recently the U. S. Rubber Laboratory, under the direction of P. Tawney, devised a new synthesis carried out with allyl acetate and formaldehyde to give 1,2,4-butane triacetate which was readily hydrolysed to butanetriol (U. S. Rubber Company Guarterly Report, May 1948). Working with pure 1,2,4-butanetriol prepared by an improved technique of the Wagner method, the U. S. Ruval Laboratory in 1948 nitrated the butanetricl on a laboratory and a pilot plant scale (Reference a).

#### Raferences: 3

(a) J. A. Gallaghan, F. Jacri, J. Bednarik, and F. McCollum, <u>The Synthesis of 1,2,4-Butane-</u> triol and the Evaluation of Its Trinstrate, U. S. Naval Powder Pactory Technical Report No. 19, 10 September 1948.

(b) Also see the following Picstinny Arsens: Technical Reports on Butanetriol Trinitrate: 1755 and 1786.

<sup>B</sup>See rootnote 1, page 10.

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Composition A-3

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Composition:		Molecular Weight:		227
RDX 91		Oxygen Beleace: CO <sub>2</sub> % CO %	-48	
Max 9				-23
			,000 psi	1.65
C/H Ratio		Molting Point: "C	·····	
		Freezing Point: 'C	4 <b>- 1</b> -1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1	
Impect Sensitivity, 2 Kg Wt: Bureau of Mincs Apparatus, cm 100+ Sample Wt 20 mg		Boiling Point: "C Refrective Index, 51%	<u> </u>	
Picatinny Arsenal Apparatus, in. Sample Wt, mg	16 17	ng		
		n		
Friction Pondulum Test: Steel Shoe Uneffe		Vacrom Stability Test:		
Steel Shoe Unaffe Fiber Shoe Unaffe		cc/40 Hrs, at 90°C		
		100°C		0.3
Rifle Buildt Import Test: Trials		120°C		0.6
% Explosions 0 Partials 0 Burned 0		135*C		
		150°C		
		200 Gram Bemb Sand Test:		
Unaffected 100		Sand, gm		51.5
Explosion Temperature: *C		Sensitivity to Initiation:	<u> </u>	
Seconds, 0.1 (no cop used)		Minimum Detenating	Chorge, gm	
1		Mercury Fulminate	•	0.22*
5 Decomposes 250	)	Lead Azide		0.25*
10 15		* Alternative initi	ating charg	68
20		Bellistic Morter, % TN		135
· · · · · · · · · · · · · · · · · · ·		Trous! Test, % TNT:		
75°C Internetional Heat Test: % Loss in 48 Hrs		Plate Dent Turt: Method	(b) B	в
100°C Heat Tast:	•	Condition	Pressed	Pressed
% Loss, 1st 48 Hrs	0.15	Confined	No	No
% Loss, 2nd 48 Hrs	0.15	Density, gm/cc	1.61	1.20
Explosion in 100 Hrs	None	Brisance, % TNT	126	75
Flommobility Index:	195	Detension Rate: Confinement	(c)	None
Hygrescepicity: % 30°C, 90% RH	0.0	Condition Charge Diameter, in.		Pressed 1.0
Veletility: 50°C, 15 days	7.03	Density, gm/cc Rate, meters/second		1.59 81 <b>00</b>

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Composition A-3

Frequentation Test:		Shaper Charge Effectiveness, TNT = 100:		
90 mm HE, M71 Projectile, Lot V	WC-91:	Glass Cones Steel Cones		
Density, gm/cc	1.62	Hole Volume		
Charge Wt, Ib	2.102	Hole Depth		
Total No. of Fregments:		Color: White buff		
For TNT	703	Color: White-buff		
For Subject HE	1138	Principal Uses: HE, SAP, AP projectiles;		
3 inch HE, M42A1 Projectile, Lot	KC-5:	Shaped Charges		
Density, gm/cc	1.64			
Charge Wt, Ib	0.861			
Total No. of Fragments:		Method of Looding: Pressed		
For TINT	514	riessea		
For Subject HE	710			
		Loading Density: gm/cc psi x 10 <sup>3</sup>		
Fregment Velocity: ft/sec		-3 12 1.47 1.65		
At 9 ft	2800			
At 251/2 ft	2530	Storage:		
Density, gm/cc	1.61	Method Dry		
Blast (Relative to TNT);	<u> </u>	l lazard Class (Quantity-Distance) Class 9		
Air:		Compatibility Group Group I		
Peak Pressure				
Inipulse		E. Jotion 3 not exude at 65°C when waxes multing sharply at or above 75°C are used.		
Energy		acting snarpiy at or above () - c are used.		
		Preparation:		
Air, Confined:		A water slurry of FDX is heated to 100°C		
Impulse		with agitation. Wax and a wetting agent are		
Under Water:		added and the mixture, under agitation, is cooled below the melting point of the wax.		
Peak Pressure		The wax costed RDX is collected on a filter		
Impulse		and air dried at 75°C.		
Energy		Effect of Temperature on Fate of Detonation: (e)		
Undergrownd:		16 hrs at, °C -54 21		
Peak Pressure		Density, gm/cc 1.51 1.51		
impulse		Rate, m/sec 7600 7620		
Energy		Booster Sensitivity Test: (d)		
		Condition Pressed		
		Tetryl, gm 100 Wax, in. for 525 Detonation 1.70		
		Wax, in. for 50% Detonation 1.70 Density, gm/cc 1.62		
		Heat of:		
		Combustion, cel/gm 1210		

### Composition A-3

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### Compatibility with Metals:

Dry - Aluminum, stainless steel, mild steel, mild steel coated with acid-proof black paint and mild steel plated with nickel or zinc are unaffected. Copper, magnesium, magnesium-aluminum alloy, brass and mild steel plated with cadmium or copper are slightly affected.

Wet - Stainless steel is unaffected. Copper, aluminum, magnesium, brass, mild steel, mild steel coated with acid-proof black paint and mild steel plated with copper, cadmium, nickel or zinc are slightly affected.

#### Origin:

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Developed by the British during World War II as RDX and beeswax. Subsequent changes in the United States replaced beeswax with synthetic wares, changed the granulation of RDX and improved the method of manufacture.

#### Destruction by Chemical Decomposition:

RDX Composition A-3 (RDX/wax, 91/9) is decomposed by adding it slowly to 25 times its weight of boiling 5% sodium hydroxide. Boiling of the solution is continued for one-half hour.

## References: 9

(a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(c) G. H. Messerly, The Rate of Detonation of Various Explosive Compounds, OSRD Report No. 1219, 22 February 1943.

M. D. Hurwitz, The Bate of Detonation of Various Compounds and Mixtures, OSRD Report No. 5611, 15 January 1946.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for Tetryl in Boosters</u>, NOL Memo 10,303, dated 15 June 1949.

(e) W. F. McGarry and T. W. Stevens, Detonation Rat 3 of the More Important Military Explosives at Several Different Temperatures, PATR No. 2383. November 1956.

(f) Also see the following Picatinny Arsenal Technical Reports on RDX Composition A-3:

<u>o</u>	<u>1</u>	2	3	<u>4</u>	2	<u>6</u>	<u>7</u>	8	2
1380 1910	1451 1761	1492 2112	1493	1424 1614 1634 2154	1325 1585 1595 1715 1835 2235	1556 19 <b>3</b> 6	1637 1737 1797	1338 1388 1723 1835	1639 2179

<sup>9</sup>See footnote 1, page 10.

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### Composition B

Composition:		Molecular Weight:		224
<b>%</b>		Oxygen Belance:		
rdx 60		CO, % CO %		-43 10
THT 40			Cast	1.65
Wax, added 1		Melting Puint: *C	(1)	78-80
C /M Batia		Freezing Point: *C		
C/H Ratio				
Import Sensitivity, 2 Kg Wit: Bureou of Mines Apparatus, cm	75	Soiling Point: 'C		
Sample Wt 20 mg Picatinuy Arsenal Apparatus, in	14	Refrective Index, na		
Somple Wt, mg	19	n <sub>22</sub>		
	<u></u>	n		
Friction Pendulum Test:		Vocuum Stability Test:		
Steel Shoe Unaffect Fiber Shoe Unaffect		cc/40 Hrs, at 90°C		
		100°C		0.7
Rifle Bullet Impect Test: Trials		120°C		0.9
5 Supplesions 3		135°C		
Partials 13		150°C		11+
Burned 4		200 Grem Somb Sond Tes		
Unoffected 80		Sond, gm		54.0
Explosion Temperature: *C		Sensitivity to Initiation:		
Seconds, 0.1 (no cop used) 526		Minimum Detonating C	harge, gm	
1 368 5 Decomposes 278		Mercury Fulminate Lead Azide		0,22* 0,20*
10 255				
15 > 250		* Alternative initia		
<b>20 ≥</b> 250		Bellistic Morter, % TNT:	<u>(a)</u>	133
75°C International Heat Test:		Trouzi Test, % 1NT:	(๖)	130
75°C International Hout Test: % Loss in 48 Hrs		Plate Dent Test:	(c)	_
		Method		B
100°C Heat Test:		Condition Confined		Cast No
% Loss, 1st 48 Hrs	0.2	Density, gm/cc		1.71
% Loss, 2nd 48 Hrs	0.2 Nore	Brisance, % TNT		132
Explosion in 100 Hrs	None			
Fimmebility Index:	177	Detenstien Rete:     Confinement		None
-		Condition		Cast
Hygrescepicity: % 30°C, 90% RH	0.02	Charge Diameter, in.		1.0
34 A		Density, gm/cc		1.68
Vələtility:		Rate, meters/second		7540

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#### Cr\_position B Decomposition Equation: Oxygen, atoms/sec (Z/sec) (d) Cast Reactor Scientivity Yesi. Condition Tetryl, gm 100 Heat, kilocalorie/mole (ΔH, kcal/mol) Wax, in. for 50% Detonation 1.40 Wax, gm Temperature Range, \*C Density, gm/cc 1.65 Phase (e) 2790 Heat of: Armor Plate Impact Test: (e) Combustion, col/gm Explosion, col/gm 1240 **60 mm Morter Projectile:** Gas Volume, cc/gm 50% Inert, Velocity, ft/sec 209 Formation, col/gm Aluminum Sineness (1) 8**.0** Fusion, col/gm 500-16 General Purpose Bombs: Specific Huet: col/gm/\*C (3) Plate Thickness, inches °C Trials % Inert 0.376 0.354 0.341 0.312 0.235 0.220 0.25<sup>1</sup> 0.305 -75 0 75 85 1 4 100 6 1% 50 25 50 90 100 $1\frac{1}{2}$ 2 0 134 0 Burning Ratu: cm/sec Bomb Drop Test: Thermal Conductivity: ccil/sec/cm/\*C T7, 2000-It: Semi-Armer-Piercing Bemb vs Concrete: Max Safe Drop, ft Coefficient of Expension: Linear, %/\*C 500-Ib General Purpose Bomb vs C No Seal Seal Volume, %/\*C rieight, ft 4000 400 65 Trials 39 Hardness, Mohs' Scale: Unafrected 58 36 Low Order 2 2 Young's Medulus: High Order 5 1 E', dynes/cm<sup>3</sup> E, Ib/inch<sup>2</sup> 1000-Ib General Purpose Bomb vs Concrete: Density, gm/cc Height, ft Compressive Strength: Ib/inch<sup>2</sup> (b) 1610-2580 Trials 1.68 Density, gm/cc Unaffected Vapor Prossure: \*C Low C fer mm Mercury High Order

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### AMCP 706-177

### Composition B

Person and

Fragmentation Test:		Shaped Charge Effectiveness, $TNT = 100$ :				
90 mm HE, M71 Projectile, Lat '	WC-91.	(g) (h) Glass Cones Steel Conec				
Density, gm/cc	1.65	Hole Volume 178 162				
Charge Wt, Ib	2.187	Hole Depth 125 148				
CHUIDE MIL ID	E+101	noie Deptin 12.7 140				
Total No. of Fragments:		Color: Yellow-byour				
For TNT	703	Color: Yellow-brown				
For Subject HE	<del>99</del> 8					
3 inch HE, M42A1 Projectile, Lot	YC L	Principel Uses: Fragmentation bombs, HE projectiles, grenades, shaped				
Density, gm/cc	1.67	charges				
• •	0.662					
Charge Wt, Ib	0.000					
Total No. of Fregments:		Method of Looding: Crai				
For TNT	514	Method of Looding: Crai				
For Subject HE	701					
		Looding Density: gm/cc 1.68				
Fregment Velocity: ft/sec						
At 9 ft	2940	Education in the second se				
At 25½ ft Density, gm/cc	2680 1.68	Storege:				
Density, gm/cc	1.00	Method Dry				
last (Relative to TNT):	(1)	Hazard Class (Quantity-Distance) Class 9				
Air:		Compatibility Group Group I				
Peak Pressure	110					
Impulse	110	Exudation Very slight when stored at 71°C				
Energy	116					
Ale Conflued.		Origin:				
Air, Confined: Impulse	75					
· · · ·		RDX Composition B was developed by the British between World War I and World War II.				
Under Water:		It was standardized by the United States				
Peak Pressure	110	early in World War II.				
Impulse	108	Effect of Temperature on				
Energy	121	Rate of Detonation: (i)				
Underground:		16 hrs at, <sup>o</sup> C -54 24				
Peak Pressure	104	Density, gm/cc 1.69 1.69				
Impulse	97	Rate, m/sec 7720 7660				
Energy	21	Bulk Modulus at Room (())				
Crater redius cubed	107	Tempersture (25°-30°C):				
	'	% Wax in Comp B 1 2 3				
		Drnes/cm <sup>2</sup> x 10 <sup>-10</sup> 5.10 3.5% 2.34 Density, mm/cc 1.72 1.70 1.4%				
		Viscosity, poises:				
		Temp, 0300 3.1				

#### Composition B

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#### Compatibility with Metals:

Dry - Magnesium, aluminum, magnesium-aluminum alloy, mild steel, stainless steel, mild steel coated with acid-proof black paint and mild steel plated with zinc or nickel are unaffected. Copper, brass and mild steel plated with copper or cadmium are slightly affected.

Wet - Aluminum and stainless steel are unaffected. Copper, brass, mild steel, mild steel coated with acid-proof black paint and mild steel plated with cadmius, copper, nickel or zine are slightly affected. Magnesium and magnesium-aluminum alloy are more heavily affected.

#### Preparation:

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Water wet RDX is added slowly with stirring to molten  $T^{mr}$  melted in a steam-jacketed kettle at a temperature of 100°C. Some water is poured off and heating and stirring are continued until all moisture is evaporated. Wax is then added and when thoroughly mixed, the composition is cooled to a satisfactory pouring temperature. It is cast directly into ammunition components or in the form of chips when Composition B is to be stored.

#### Destruction by Chemical Decomposition:

RDX Composition B is decomposed in 12 parts by weight of technical grade acetone heated to  $45^{\circ}$ C. While this is stirred vigorously, there is added 12 parts of a solution, heated to  $70^{\circ}$ C, of 1 part sodium sulfide (Na<sub>2</sub>S<sup>•</sup>9H<sub>2</sub>O) in 4 parts water. The sulfide solution is added slowly so that the temperature of the acetone solution does not rise above  $60^{\circ}$ C. After addition grade complete, stirring is continued for one-half hour.

## References: 10

(a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III - Miscellaneous Sensiti..ty Tests; Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Second Revision, NAVORD Report No. 87-46, 26 July 1946.

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> Tetryl in Boosters, NOL Memo 10,303, 15 June 1949.

(e) Jummittee of Divisions 2 and 8, NDRC, Report on HEV and Tritonal, CERD Report No. 5406, 31 July 1945.

(f) W. R. Tomlinson, Jr., <u>Blast Effects of Bomb Explusives</u>, PA Tech Div Lecture, 9 April 1948.

(g) Eastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Sec III, Variation of Cavity Effect with Explosive Composition, NDRC Contract W572-ORD-5723.

(h) Eastern Laboratory du Pont, <u>Investigation of Cavity Fffect</u>, Final Report, E Lab du Pont, Contract W-672-ORD-5723, 18 September 1943.

(i) W. F. McGarry and T. W. Stevens, Detonation Rates of the More Important Military Explosives at Several Different Temperatures, PATR No. 2383, November, 1956.

<sup>10</sup>See footnote 1, page 10.

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### Composition B

(j) W. S. Crawer, <u>Bulk Compressibility Date on Several High Explosives</u>, NAVORD Report No. 4380, 15 September 1955.

(k) Also see the following Picatinny Arsenal Technical Reports on RDX Composition B:

<u>0</u>	1	2	3	4	2	<u>6</u>	I	<u>8</u>	2
1360 1530 2100 2160 2190	1211 1451 2131 2151	1402 1482 1592	1313 1433 1803 1983 2053 2063 2103 2233	1:24 1424 1944 2004 2104	1325 1435 1585 1595 1865 1885 2055 2125	1466 1476 1556 1756 1956 225	1207 1437 1457 1'137 1797 2007 2147	1338 1368 1438 1458 1688 1728 1828 1838	1339 1379 1469 1819 ~719
					2155 2175 2235			1978 2008 2138 2168	

(1) C. Lenchitz, W. Beach and R. Valicky, Enthelpy Changes, Heat of Fusion and Specific Heat of Fusic Explosives, PATR No. 2504, January 1959.

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### Composition B, Desensitized

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Composition: %	<u>I*</u>	<u>II**</u>	Molecular Weight:	<u>I*</u> Cyclouite	II**
RIX	60 40	55.2 40.0	Oxygen Balence;		
TNT Wax, added, (Stanolind	40	40.0		Cyclonite	See Comp
or Aristowsx, 1650/ 1700F)	5			Cyclonite	See Comp
Vinylseal (MA28-14), added	2		Density: gm/re Cast	1.65	1.65
Vistanex (Bl2O) Albscer Wax		1.2 3.6	Molting Point: °C		
C/H Ratio			Freezing Point: "C		
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	<u>I*</u> 95	<u>11**</u>	Boiling Point: "C		
Sample Wt 20 mg	14	10	Refractive Index, no		
Picationy Arsenal Apparatus, in. Sample Wt, mg	17	13 16	n <mark>o</mark> n ·		
	-1		n <sup>o</sup> 20		
Friction Pendulum Test:			Vacuum Stability Test:	<u>I</u> #	<u>II**</u>
Stuel Shoe Unaffect			cc/40 Hrs, at		
Fiber Shoe Unaffed	ted		90°C		
Rifle Bullet Import Test: Trials			- 100°C		
• • • • • • • • • • • • • • • • • • • •	I*	11**	120°C	U.99	0.92
% Explosions	<u>1</u>	0	135°C		
Portiols	õ	0	150°C	11+	11+
Burned	5	õ	200 Grem Bomb Sond Test:	<u>I*</u>	II**
Unoffected	95	100	Sand, gm	<u>52.7</u>	55.0
Explecion Te areture: °C Seconds, 0.1 (no cap used) 1 5 Decomposes	<u>I*</u> 260	<u>II**</u> 270	Sensitivity to Initiation: Minimum Detonating Cha Mercury Fulminate Lead Azide	<u>I*</u> rge, gm 0.22	<u>11**</u>
10	-		Tetryl	~~~~	V
15					
20			Bellistic Morter, % TNT:		
75°C International Heat Test:			Trouzi Test, % TNT:		
% Loss in 48 Hrs			Pists Dent Test: Method		
10. C Heet Test:	<u>I*</u>	<u> II**</u>	Condition		
% Loss, 1st 48 Hrs	0.05	0.12	Confined		
% Loss, 2nd 48 Hrs	0.19	0.18	Density, gm/cc		
Explosion in 100 Hrs	None	None	Brisance, % TNT		
Flammability Index:			- Detonation Rote: Confinement		
			- Condition		
Hygroscopicity: %					
30°C, 90% RH	0.00	0.00	Charge Diameter, in.		
Veistility:	Nil	Nil .	Density, gm/cc		
	+		Rate, meters/second		

\*Desensitized Comp P, designated I, uses emploified wax. \*\*Desensitized Comp B, designated II, uses conted RDX.

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### Composition B, Desensitized

Fregmentation Test:		Shaped Charge Effectiveness, TNT = 100:				
90 mm HE, M71 Projectile, Dersity, gm/cc Charge Wt, Ib	Lot WC-91:		Hole Volur Hole Depth		ies Steel (	Cones
<b>Total No. of Fragments:</b> Cor TNT			Color:		Yellow-	prom
For Subject HE			Principal Use		Bombs	
3 inch HE, M42A1 Projectile	, Lot <u>K</u> C-5:	T <b>T</b> ¥¥				
Density, gm/cc	1.65	<u>11**</u> 1.65	1			
Charge Wt, Ib	0.87	0.86				4
Total No. of Fragments:			Advised of La			
For TNT	514	5⊥`	Meinod of La	aang:	Cast	
For Subject HE	609	659				
			Louding Dens	ity: gm/cc	1.65	
Fregment Velocity: ft/sec At 9 ft At 25% ft			Storage:			
Density, gm/cc			Method			Dry
Blast (Relative to TNT);			Hozard Cla	ss (Quantity	Distance)	Class 9
Air: Peak Pressure			Compatibil	ity Group		Group I
Impulse			Exudation			
Energy						
Air, Confined:			Viscosity,	poises:	<u>I*</u>	<u>II**</u>
Impulse			Тетр, 83 95	°c °3	3.5 2.6	3.1 2.7
Under Water: Peak Pressure			References			
Impulse			References	<b>-</b>		
Energy				Reports on	wing Ficat RDX Compo	inny Arsenal sition B,
Underground: Peak Pressure			<u>1</u>	<u>3</u>	<u>5</u>	6
Impulse			2151	1313	1435	1756
Energy				2053	1869	±, )=
*Desensitized Comp B, des emulsified wax. **Desensitized Comp B, des coated EDX.						

### Compreition C

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Composition: %		Melecular Weight:	
RDX	88.3	Oxygen Belence: CO <sub>2</sub> %	
Platicizer, non- explosive	11.7*	CO % Density: gm/cc	
*Nonexplosive oily plo 0.6% lecithin.	asticizer containing	Maing Point: *C	
C/H Ratio		Freezing Puint: 'C	
Impact Sanristvity, 2 Kg We: Bureau of Mines Apparatus	, cm 100+	Boiling Point: "C	
Sampie W1 20 mg Picatinny Arsenal Apparatu	us, in,	Refrective Index, n20	
Sample Wt, mg		ពង្គ	
P-1-1-1		n <sub>20</sub>	
Friction Pondulum Test: Steel Since		Vocuum Stability Test:	
Silver Shoe		cc/40 Hrs, at 90°C	
		- 100°C	0.3
Rifle Bullat Ingener Test: 1	<b>Frials</b>	126 C	0.7
Explasions	ж о	135°C	-
Partials	0	150°C	
Burned	0	200 Green Bernh Sond Text:	
Unoffected 1	00	Sand, gin	46.5
Explorion Temperature:	•c	Sensitivity to Initiation:	
Suconds, 0.1 (no car used)	×	Minimum Detonating Charge, gm	
1 5 Decomposes	285	Mercury Fulminate	
10	207	Leod Azide	0.25
15		Tetryi	0.11
20	4	Bellistic Morter, % TNT: (a)	120
		_ Treuzi Test, % TNS:	•
75°C International Heat Test: % Loss in 48 Hrs		Plate Dont Test:	
		Method	A
100°C Heat Test:			d Tamped
% Loss, 1st 48 Hrs	c.04	Confined	Yes
% Loss, 2nd 48 Hrs	0.00	Density, gm/cc	1.58
Explosion in 100 Hrs	None	Brisonco, % TNT	112
Flemmebility Index:		- Detenation Rate:	
		Confinement	
Hygrescepicity: % 30°C, 9	5% RH 0.25	<ul> <li>Condition</li> <li>Charge Diameter, in.</li> </ul>	
		Density, gm/cc	
Valatility: 25°C, 5	days 0.00	Rote, meters/second	

100 - 100

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### Corposition C

Fragmentation Test:	Sheped Charge Effectiveness, THY = 100: (1) (g)
90 mm HE, M71 Projecting Lat WC-91:	Gloss Cones Steel Conet
Density, gm/cc	Hole Volume 113 114
Charge Wt, Ib	Hole Depth 101 14
Totul No. of Progmanite:	Color: White
For THT	Comprise with the
For Subject HE	Principal User: Plastic demolition explosive
3 linesh HE, MARA1 Projectille, Lot KC-5:	
Density, gm/cc	
Charge Wt, Ib	
Total No. of Progmants:	Method of Londing: Hand tamped
For TNT For Subject HE	
	Looding Density: gm/cc 1.49
Progmant Valuatiy: ft/sec	
At 251/2 ft	Storage:
Density, gm/cc	Method Dry
Blast (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9
Ain	Compatibility Group Group I
Peak Pressure	
Impulse	Exudation Exudes above 40°C
Energy	· · · · · · · · · · · · · · · · · · ·
Air, Confined:	Plasticity:
Impulse	Below 0°C Brittle (0°C)
AL- 4 MA-A	0-40°C Plastic
Under Weter: Peok Pressure	Above 40°C Exuides (40°C)
Impulse	Daferences:
Energy	Sea references for Composition C-4.
Underground: Pack Pressure	
Impulse	
Energy	

	Compos	ition C-2		AMCP 706-177
Composition: 96		Melecular Weigl.		<u></u>
RDX 78.7 THT 5.0 DHT 12.0		Oxygen Belence: CO <sub>2</sub> % CO %		
MAT 2.7 NC 0.6		Dunsity: gm/cc		
Solvent 1.0		Maiting Palat: "C		
C/H Rotio		Freezing Paint: "C		
Impact Sensitivity, 2 Kg Wt: Bureou of Mines Apparotus, cm	90	Boiling Point: *C		_
Sample Wt 20 mg Picotinny Arsenal Apparatus, in. Sample Wt, mg		Refrective Index, ng ng ng		
Fristian Pandulum Test:				
Steel Shoe Fiber Shoe		Vacuum Stability Test: cc/40 Hrs, at 90°C		
Riffe Bullet Impact Test: Tricks		- 100°C		2.0
%		120°C		9.0
Explosions 0		135°C		
Partials 20		150°C		
Burned 0		200 Grom Bomb Sond Test	*	
Unoffected 80		Sand, gm		47.5
Explosion Temperature: *C		Sensitivity to Initiation:		
Seconds, 0.1 (no cap used)		Minimum Detonating Cl	horge, gm	
1 5 Decomposes 285		Mercury Fulminate		
10		Lead Azide		0.25
15		Tetryl		0.10
20		Ballistic Morter, % TNT:	(.)	126
75°C International Hant Test:		Trouzi Teot, % TNT:		
% Loss in 48 Hrs		Plate Dant Test: Method	(c)	В
100°C Heat Test:		Condition	Haa	d tamped
% Loss, 1st 48 Hrs	1.8	Confined		No
% Loss, 2nd 48 Hrs	1.4	Density, gm/cc		1.52
Explosion in 100 Hrs	None	Brisance, % TNT		111
flommobility Index:	178	- Detenction Rate: Confinement	(ð)	None
Hygreecepicity: % 30°C, 95% RH	0.55	Condition Charge Incometer, in.	Ha	nd tamped 2.0
Velatility: 25°C, 5 days	0.00	- Density, gm/cc Rate, ineters/second		1.57 7660

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### Composition C-2

Frequentation Test:	Shaped Charge Effectiveness, TNT = 190:
90 mm HE, M71 Prejectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Gloss Cones Steel Cones Hole Volume Hole Depth
Tetal No. of Fragments: For TNT For Subject HE	Color: White
3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib	Principal Uses: Plastic demolition explosive
Tetel No. of Fregments: For TNT	Method of Looding: Hand tamped
For Subject HE Freqment Velocity: ft/sec	Losding Density: gm/cc 1.57
At 9 ft At 25½ ft	Storoge:
Density, gm/cc	Method Dry
Blast (Relative to TNT)-	Hozord Class (Quantity-Distance) Class 9
Air: Peak Pressure Impulse Energy	Compotibility Group Group I Exudation Volatilizes above 52 <sup>0</sup> C
Air, Confined: Impulse Under Water:	Plasticity:Belcw 0°CPlastic (-30°C)0-40°CPlasticabove 40°CHard (52°C)*
Peak Pressure hpulse Energy	*Due to volitalization of plasticizer. References:
Undchyround: Peak Pressure Impulsy Energy	See references for Composition C-4.

Composition C-3

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Composition:	,	Molecular Weight:	
<b>%</b>		Oxyg.n Colonsa:	
RDX Tetryl	זי	CO. *	
INT	3 4	CO %	
DNT	10	Providence and face	
NIFT	5 1	Density: gm/cc	
	-	Moltine Point: "C	
C/H Rotio		Freezing Point: *C	
upect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	100+	Bailing Point: "C	
Sample Wt 20 mg	• ).	Refrective Index, na	
Picatinny Arsenal Apparatus, in. Sample Wt, mg	14 33	n <mark>o</mark>	
		ng	
Friction Pendulum Test:		Vacuum Stability Test:	
	ffected	cc/40 Hrs, at	
Fiber Shoe Una:	ffected	90°C	
Rifle Bullet Import Test: Trials		100°C	1.21
•		120°C _	11+
Suplosions 0		135*0	
Partials 40		150°C	
Burned 0		2( ) Grem Bemb 5. nd Test:	·····
Unaffected 60		Sand, gm	53.1
Explosion Temperature: 'C	····· <del>································</del>	Sensitivity to Initistien:	
Seconds, 0.1 (no cop used)		Minimum Detonating Charge, gm	I
1		Mercury Fulminate	
5 Decomposes 280		Leod Azide	0.20
10		Tetryi	0.08
15			
20		Bellistic Morter, % TNT: (a)	126
75°C International Hoat Test:		Treuzi Test, % TNT: (b)	117
% Loss in /8 Hrs		Flote Dont Test: (c)	
		Method	B
100°C Heat Test:		Condition Ha	ind tamped
% Loss, 1st 48 Hrs	3.20	Confined	No
% Loss, 2nd 48 Hrs	1.63	Density, gm/cc	1.57
Explosion in 100 Hrs	None	Brisance, % TINT	118
		Detenstien Rate: (d)	
flammability index:		Confinement	None
		Condition He	und tamped
Hygratespicity: % 30°C, 95% RH	2.4	Charge Diameter, in.	1.0
		Density, gm/cc	1.60
Velatility: 25°C, 5 days	1.15		

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### Composition 0-3

Fregmentation Test:		Shaped Charge Effectiveness, TN'T == 10	<b>):</b>
70 mm HE, M71 Projestilo, Lat	WC-91:	Glass Cones Steel Co	K185
Density gm/cc	158	Hole Volume	
Charge Wt, ib	2045	Hole Depth	•
Total No. of Fragments:		Color: Yellov	
For TNT	703	Carden: IETTOM	
For Subject HE	944	Principal Vaca: Plastic demolitie	
3 inch HE, MASA1 Projectile, Le	# KC-5:	Principal Uses: Plastic demolitic	M CAPIOSIV
Density, gm/cc	1.60		
Charge Wt, Ib	0.842		
Total No. of Fragments:		Method of Londing: Band to	
For TNT	514	And u	apea
For Subject HE	671		
Language Walashar & Jaco		Looding Density: gm/cc	1.58
Fregment Velocity: ft/soc At 9 ft At 25½ ft		Sivege:	
Density, gm/cc		Method	Dry
liest (Relative to TNT):			Class 9
Air:		Compatibility Group	Group I
Peak Pressure	105		
Impulse	109	Exudation Exudes at 77°C	
Energy			
Air. Confined:		Plasticity:	
Impulse		Belov 0°C Ha	rd (-29°0)
			astic
Under Water:		Above 40°C Ex	udes (77°C)
Peak Pressure		Booster Sensitivity Test: (h)	)
Impulse		Lood Ver Lengt OIVI OF 1680; (II.	,
Energy			essed
Underground:		Tetryl, gm Wax, in. for 50% Detonation	1.00 1.36
Peak Pressure			1.62
Impulse		References:	
Energy		See references for Composition	a C-4.

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### Composition C-4

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Composition:		Moreculer Weight:	
RDK	91	Oxygen Balanca:	
		CO. %	
Plasticizer, non- explosive	9*		
		Density: gm/cc	
* Contains polyisobutylen 1.6% and di(2-ethylhes		Molting Point: "C	
C/H Ratio	с	Freezing Point: "C	
impact Sanskivity, 2 Kg W?:		Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	100+	Refractive Index, no	
Picatinny Arsenal Apparatus, in	. 19	1	
Sample Wt, mg	27	n <sub>25</sub>	
		n.,	
Friction Predulum Test:		Vacuum Stability Test:	
Steel Shoe Un	affected	cc/40 Hrs. at	
Filme Shoe Un	affected	90°C	
		- 100°C	0.26
Rifle Bullet Impect Test: Trial	6	120°C	
Explosions 0		135°C	
Explosions 0 Partials 0		150°C	
Burned 20			
		200 Grem Bomb Send Test:	<i></i>
Unoffected 80		Sond, gm	55.7
Explosion Tomperature: **	2	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)		Minimum Detonating Charge,	gm
1		Mercury Fulminote	
•	90	Leod Azide	0.20
10		Tetryl	0.10
15		Ballistic Merter, % TNT: (a)	130
20		Treuzi Test, % TNT:	
75°C In: Ametional New Test:			
% Loss in 48 Hrs		Plate Cont Test: (c)	P
		-	-
100°C Hert Test:		Condition Confined	Hand tamped
96 Loss, At 48 Hrs	0.13		No 1.60
% Less, 2nd 48 Hrs	0.00	Density, gm/cc	115
Explacion in 100 Hrs	lione	Brisonce, % TNT	LT)
		- Detenotien Rate: (d)	
Flemmebility Index:		Confinement	None
		Condition	Hand tamped
<b>Hygroscopicity: % 30°C,</b> 95% F	H N11	Charge Diameter, in.	1.0
	·····	- Density, gm/cc	1,59
Veletility:		Ratu, meters/second	8040

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Composition C-4

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Pregmentation Yer	Shoped Charge Effectives		٨.	
	anabes sue la pringrate	nandy 1141 == 74	<b>~</b> •	
90 mm HE, M71 Projectile, Lot WC-91:	Gloss Co	ines Steel Co	57.45	
Density, gm/cc	Hole Volume			
Charge Wt, Ib	Hole Depth			
cal Nr. of Progmants:	Celer:	Light brow		
For TNT		TIRUC DIOM	4	
For Subject HE	Principal Uses: Plasti	c demolition	explosive	
3 inch HE, M42A1 Projectik , Let KC-5:			•	
Density, gm/cc				
Charge Wt, Ib				
Total No. of Fragments:	Method of Looding:	Hand	tamped	
For TNT		Here	og margin	
For Subject HE				
	Looding Density: gm/cc	:	1.60	
Fragmank Velocity: ft/sec At 9 ft				
At 251/2 ft	Storage:			
Density, gm/cc				
	Method	D	ry	
Blast (Relative to TNT):	Hazard Class (Quantity	<b>-Distance)</b> C	LESS 9	
Air: Peak Pressure	Compatibility Group	Gi	roup I	
Impulse	Exudation	None at '	77 <sup>o</sup> c	
Energy				
		<u></u>		
Air, Confined: impulse	Effect of Temperatur Rate of Detonation:	re on	(1)	
Under Water:	16 hrs at, °C	-54	21	
Peak Pressure	Density, gm/cc	1.36	1.35	1.5
Impulse	Rate, m/sec	7020	7040	
Energy	Plasticity:			
Underground:	Below O°C		: (-57°c)	
Peak Pressure	0-40 <sup>0</sup> C Above 40 <sup>0</sup> C	Plastic	ε ( <i>τ</i> .°c)	
Imputse		LTERCIO	- (I, C)	
Energy				
				ł

### Compositions C, C-2, C-3, C-4

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#### Preparation:

In manufacturing Composition C-3, the mixed plasticizing agent is heated in a melting kettle at 100°C. Water-vet RDK is added and heating and stirring are continued until all the vater is evaporated. This mixture is then cooled and hand pressed into demolition blocks or special item emmunition.

Composition C-4 is preserved by hand kneading and rolling, or in a Schrader Bowl mixer, RDX of 44 micron size or less with the polyisobutylene-plasticizer previously made up in other. The thoroughly blended explosive is dried in air at  $60^{\circ}$ C and loosely packed by hand tamping to its miximum density.

#### Origin:

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Developed by the British during World War II as a plastic explosive which could be hand shaped. It was standardized in the United States during World War II and subsequent development led to mixtures designated C-2, C-3 and C-4.

#### Destruction by Chemical Decomposition:

Composition C-3 is decomposed by adding it slowly to a solution composed of 1 1/4 parts solution hydroxide, 11 parts vater, and 4 parts 95% alcohol, heated to  $50^{\circ}$ C. After addition of Composition C-3 is complete, the solution is heated to  $80^{\circ}$ C and maintained at this temperature for 15 minutes.

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<sup>11</sup>See footnote 1, page 10,

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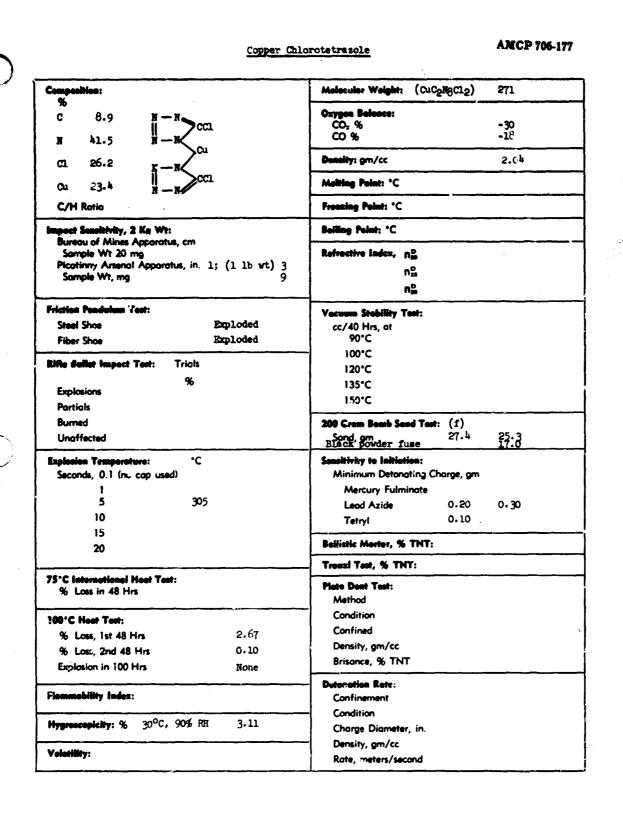
### Compositions C, C-2, C-3, C-4

(i) W. F. McGarry and T. W. Stevens, <u>Detonation Rates of the More Important Military Emplo</u> sives at Several Temperatures, PATE No. 333, November 1956.

(j) Also see the following Picatinny Arsenal Technical Reports on RDK Composition C:

	<u>0</u>	1	3	<u>4</u>	٤	<u>6</u>	Ĩ	<u>8</u>	2
Comp C	1260	~	1293					1518 1838	
Comp C-2 Comp C-3		1611	<b>1293</b> 1713	2154	1595 1695 1885	1416 1416 1556	1797	1518 1518 2028	
Comp C-4					2007	1766 1766	1907	1828 1958	1819

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#### Copper Chlorotetrasole

Fregmentellen Test:	Shaped Cherge Montyonen, TNT = 100:					
98 mm HE, M71 Projectile, Let WC-91:	Glass Cones Steel Cones					
Density, gm/cc	Hole Volume					
Chorge Wt, Ib	Hole Dapth	í.				
Total No. of Fragments:	Celon Blue					
For TNT						
For Subject HE	Principal Uses: Primary explosive					
3 inch HE, M42A1 Projectile, Let KC-5:		<u> </u>				
Density, gm/cc						
Charge Wt, Ib		г. Э				
Total No. of Fragments:	Mothed of Looding: Pressod	·				
For TNT						
For Subject HE						
	Looding Density: gm/cc psi x 103	(c <u>)</u>				
Frequent Velocity: ft/sec	10 20 40 70 1.49 1.63 1.74 1.86					
At 9 ft						
At 25% ft	Storege:					
Density, gm/cc	Method Wet					
Blast (Relative to TNT):	Hazard Class (Quantity-Division) Class	₿ 2.				
Air: Pack Pressure	Compatibility Grc	рМ				
Impulse	Exudation None					
Energy						
Changy		<i>(</i> )				
Air, Ceefined:	Stab Sensitivity:	(c)				
Impulse	Density Firing Point (inch-ounces gm/cc 05 505 1005	<b>)</b> <sup>1</sup>				
Under Water:						
Peak Pressure	1.49 9 11 15 1.63 8.5 10 12					
Impulse	1.63 8.5 10 12 1.74 6 , 9					
Energy	1.86 4 5 6					
Underground:	Heat of:					
Pack Protecter	Explosion, cal/gm 432					
Impulse Energy	Specific Heat, cal/gm/ <sup>O</sup> C					
	Temp range 6 <sup>0</sup> -30 <sup>0</sup> C 0.15 Wt of *ample, gp 0.89					

#### Copper Chlorotetresole

AMCP 706-177

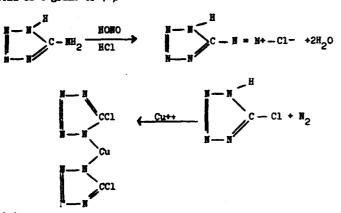
#### Proparation: (a)

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Five grams of 5-aminotetrasole are dissolved in a mixture of 200 ml of water and 70 ml of concentrated HCL. Prough herosene or nujol (which gives a slightly cleaner product) is added to provide a layer of oil approximately  $1/h^{\rm m}$  thick on the surface. With only moderate stirring and external cooling to  $10^{\circ}$ -15°C, a solution of 5 grams of sodium nitrite in 70 cc of water is added rapidly by means of a burette extending below the oil layer. Immediately after this addition, a solution of f gaw of cupric chloride in a minimum amount of water is added all at once, and stirring is continues for about 1 hour. The rest ion mixture is allowed to stand for a few minutes till the bright blue copper salt separates. The oil is removed by decantation and may be reused. The malt is filtered; washed with water alcohol, and ether; and dried - giving a yield of 6 grams or 74%.



Origin:

The copper salt of 5-chlorotetrazole was first described in 1929 by R. Stolle (with E. Schick, F. Henke-Stark and L. Krauss) who prepared the compound by resction of the diazo-nium chloride of 5-aminotetrazole with copper chloride (Ber 62A, 1123).

### References: 12

(a) R. J. Gaughrar and J. V. R. Kaufman, Synthesis and Properties of Halot-trazole Salts, PATR No. 2136, February 1955.

(b) A. M. Anzalone, J. E. Abel and A. C. Forsyth, <u>Characteristics of Explosive Substances</u>, <u>for Application in Assumition</u>, PATR No. 2179, May 1955.

(c) A. C. Forsyth, Pfc, S. Krasner and R. J. Gaughran, <u>Development of Optimum Explosive</u> Trains. An Investigation Concerning Stab Sensitivity versus Loading Density of Some Initiating <u>Compounds</u>, PATR No. 2146, February 1955.

12See foutnote 1, page 10.

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### <u>Cyanuric Triazide</u>

Composition:	Melecular Weight: (C <sub>3</sub> N <sub>12</sub> )	204		
~ C 17.6 N <sub>3</sub>	Oxygen Belence:			
	CO <sub>2</sub> % CO %	-47.1 -23.5		
и 82.4 / <sup>с</sup>				
r n	Jensity: gm/cc Crystal	1.54		
NEC C-N3	Molting Point: "C	94		
C/H Rotio	Freezing Point: *C			
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 1 kg vt 7	Boiling Point: "C			
Sample Wt 20 mg	Refrective Index, na			
Picatinny Arsenal Apparatus, in	ng			
Sample Wt, mg -	nS			
Friction Pandulum Test:	Vocuum Stability Test:			
Steel Shoe	cc/40 Hrs, at			
Fiber Shoe	90°C			
Rifle Builtst Impact Test: Trials	100°C			
•	120°C			
% Explosions	125°C			
Portials	150°C			
Burned	200 Grem Bomb Send Test:			
Unaffected	Sand, gm	32.2		
Exp <sup>2</sup> ution Temperature: "C	Sensitivity to Initiation:			
Seconds, 0.1 (no cap used) 252	Minimum Detonating Charge, gr	n		
	Mercury Fulminate	-		
5	Leod Azide	0.20		
10 15	Tetryi	0.10		
20	Ballistic Mortor, % TNT:			
	Treuzi Test, % TNT:			
75°C International Heat Tast: % Loss in 48 Hrs	Plate Dent Test:			
	Method			
100°C Heet Test:	Condition			
% Loss, 1st 48 iHrs	Confined			
% Loss, 2nd 48 Hrs	Density, gm/cc			
Explosion in 100 Hrs	Brisance, % TNT			
Figmunobility ludex:	Detenction Rote: Confinement	-		
	Condition	-		
Nyprescepicity: %	Condition Charge Diameter, in.	- 0.3		
	Density, gm/cc	1.15		

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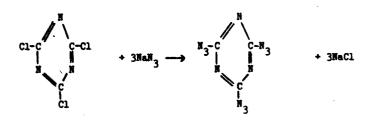
Fregmentation Test:	Shaped Charge Effectiveness,	TNT = 100:
90 mm HE, M71 Projectile, Let WC-91:	Gloss Cones	Steel Cones
Density, gm/cc	Hole Volume	
Chorge Wt, Ib	Hole Depth	
Total No. of Fregments:	Celer:	Colorless
For TNT For Subject HE		
		because of difficult
3 inch HE, M42A1 Projectile, Let KC-5:	in contro	lling sensitivity.
Density, gm/cc		
Charge Wt, Ib		
Total No. of Fragments:	Method of Londing:	Pressed
For TNT		
For Subject HE	Loading Density: gm/cc	
Paramana Malanka da tan	At 200 atmospheres At 800 atmospheres	1.4
Fragment Velocity: ft/sec At 9 ft	At 800 atmospheres	1.5
At 25½ ft	Storage:	
Density, gm/cc	Method	
viest (Relative to TNT):	Hozard Class (Quantity-Dis	tonce) Class 9
Air:	Compatibility Group	
Peak Pressure		
Impulse	Exudation	None
Energy		
Air, Confined: Impulse		
Under Water:		
Peok. Pressure		
Impulse		
Energy		
Underground:		
Peak Pressure	1	
Impulse Energy		
La rur Gy		

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#### Quanuric Triazide

#### Preparation:

By the reaction of cyanuric chloride with an aqueous solution of sodium aside:



Recrystallization should be avoided as it leads to very large crystals which explode when broken.

#### Origin:

Cyonuric Triazide was prepared in 1847 by Cahours from chlorine and methyl cyanate. Leter James improved the process (JCS 51, 268 (1887) and in 1921 E. Ott patented the preparation from cyanuric chloride and sodium azide (Ref b) Taylor and Rinkenbach prepared cyanuric triazide in a pure state and determined its properties (Ref c).

### Initiating Efficiency:

Reported to be more efficient than lead azide. Capable of initiating Explosive D.

#### Solubility:

Insoluble in water; readily soluble in hot ethanol, acetone, benzene, and ether.

#### Heat of:

Formation, cal/gm -1090 to -1138

### References: 13

(a) A. H. Blatt, <u>Compilation of Data on Organic Explosives</u>, OSRD Report No. 2014,
 29 February 1944.

- (b) Ott and Ohse, Ber <u>54</u>, 179 (1921).
- (c) Taylor and Rinkenbach, Bureau of Mines, RI 2513 (1923).
   Taylor and Rinkenbach, J Frank Inst 204, 369 (1927).

<sup>13</sup>See footnote 1, page 10.

Composition:		Meleculer Weight: (C3HGNGO6)	222
	10 <sub>2</sub>	Oxygen Balance:	~
н 2.7 нос сно	2	CO <sub>2</sub> % CO %	-22 0.0
N 37.8		Density: gm/cc Crystal	1.82
0 43.2 10.		Molting Point: *C	204
C/H Ratio 0.095		Freezing Point: "C	
impact Sanshivity, 3 Kg Wt:		Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	32	Refrective Index, ng	
Picatinny Arsenal Apparatus, in. Somple Wt, mg	8 18	nas	
	10	n <mark>a</mark>	
Friction Pendulum Test:		Vacuum Stability Test:	
Steel Shoe Explade		cc/40 Hrs, at	
Fiber Shoe Unaffec	tei	90°C	0.7
Life Bullet Impact Test: Trials		120°C	0.9
%		135°C	-
Explosions 100		150°C	2.5
Partials 0			/
Burned O		200 Gram Bomb Sand Test:	60.2
Unoffected 0		Sond, gm	5.00
xplasion Temperature: *C		Somettivity to Initiation:	
Seconds, 0.1 (no cap used) 405		Minimum Detonating Charge, g	
1 316		Mercury Fulminate	0.19*
5 Decomposes 260		Lead Azide	0.05*
10 240		* Alternative initiating chs	-
15 235 20 -		Ballistic Morter, % TNT: (2)	150
		Treast Test, % TNT: (b)	157
'5'C International Heat Test: % Loss in 48 Hrs	0.03	Plate Dent Test: (c)	
		Method	A
00°C Heat Test:		Condition Confined	Pressed Yes
% Loss, 1st 48 Hrs	باد ه		1es 1.50
% Loss, 2nd 48 Hrs	0.00	Density, gm/cc Britance % TNT	
Explosion in 100 Hrs	None	Prisonce, % TNT	135
la sur de la deserve (de la deserve de la	0779	Detenation Rate:	
lemmebility Index: (d)	278	Confinement	None
Hyprescepicity: % 25°C, 100% RH	0.02	- Condition	Pressed
	0.02	Charge Diameter, in.	1.0
/eletility:	Nil	Density, gm/cc	1.65
and the second		Rate, meters/sycond	818 <b>0</b>

Cyclonite\* (RDX)

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\*Name given by Clarence J. Bain of Picatinny Arsenal. Germans call it Hexogen; Italians call it T4; British, RDX.

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### Cyclonite (RDK)

Beaster Scalitivity Test: Condition	Decomposition Equation: (1) Oxygen, atoms/sec 10 <sup>18.5</sup>	
Tetryi, gm	(Z/sec)	
Wax, In. for 50% Detanation	Heat, kilocolorie/mole 47.5	
Wax, gm	(ΔH, kcal/mol) Temperature Range, *C 213-299	
Density, gm/cc	Phase Liquid	
Shat ef:	Armor Plate Impact Test:	
Combustion, col/gm 2285		
Explosion, col/gm 1280	60 mm Morter Projectily:	
Gas Velume, cc/gm 908	50% Inert, Velocity, ft/sec	
Formation, cal/gm -95	Akuminum Fineness	
Solution, cal/mol (28-55% MS)3) 7.169* Assuming cyclonite unimolecular	500-16 General Purpase Bembs:	
Specific heat: col/grn/*C		
° <u>c</u> ° <u>c</u>	Plate Thickness, inches	
<b>20 0.298 100 0.</b> 406	1 1	
40 0.331 120 0.427	11/4	1
60 0.360 140 0.446 80 0.384	11/2	
	17,	
Burning Rote:		
cm/sec	Bemb Drop Test:	
Thermal Conductivity:         (h)           col/sec/cm/*C         1.263         0.91 x 10 <sup>-1</sup> Density, gm/cc         1.533         6.98 x 10 <sup>-1</sup>	T7, 2000-16 Semi-Armor-Piercing Bemb vs Concret	• (
Coefficient of Expension:	Max Safe Drop, ft	1
Lineor, %/*C	500-lb Gameral Purpose Somb vs Concrete:	
Volume, %/*C	Height, ft	
Mandanan Madad Barba	Trials	
Herdness, Mohe' Scole: 2.5	Unaffected	
Young's Medulus:	Low Order	
E', dvnes/cm <sup>2</sup>	High Order	
E, Ib/inch <sup>a</sup>	1000-16 General Purpose Bomb vs Concrete:	
Density, gm/cc		l
	Height, ft	
Cace, vessive Strength: Ib/inch*	Trials	
	Unoffected	
Very Kresser:	Low Order	
C mm Mercury	High Order	

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g	yclonite (RDK)
regmentation Test:	Sheped Chorge Effectiveness, TNT = 100:
90 mm HE, M71 Projectile, Let WC-91:	Glass Cones Steel Cones
Density, gm/cc	Hole Volume
Charge Wt, H	Hole Depth
Total No. of Programme:	
For TNT	Color: White
For Subject HE	Principal Uses: Detonator base charge, and
3 inch HE, M42A1 Projectilu, Lot KC-5:	ingredient for projectils and bomb fillers
Density, gm/cc	DOMO ILLEIS
Chorge Wt, Ib	
Total No. of Progmants:	Mathed of Loading: Pressed
for TNT	
For Subject HE	
	Leeding Density: gm/cc psi x 10 <sup>3</sup> 3 5 10 12 15 20
ragment Velocity: ft/sec At 9 ft	1.46 1.52 1.60 1.63 1.65 1.66
At 25% ft	Storage:
Density, gm/cc	Method Wet
lest (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9
Air:	Compatibility Group Group M (vet)
Paok Pressure	Group L (dry)
Impulse	Exudation None
Energy	
Air, Confined:	Effect of Temperature on Rate of Detonation: (k)
Impulse	16 hrs at, <sup>o</sup> C -54 21
Under Weter:	Density, gm/cc 1.61 1.62
Peak Pressure	Rate, m/sec 8100 8050
Impulse	Effect of Temperature on
Energy	Impact Sensitivity:
Underground: Pook Pressure	Temp. PA Impect Test
Impulse	
Energy	Room 9 32.2 8
	104 5

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Cyclonite (RDX)

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Sec. 1

Solubility of Cyclonite; gm/100 gm of the following substances: (j)

Nater	Alcohol	Acetone	Benzene	Tolueno
°C         ≰           30         0.005           50         0.025           70         0.075           90         0.19           100         0.28	oc         state           0         0.040           20         0.105           40         0.240           60         0.579           78         1.195	°c         4.4           20         7.3           40         12.5           60         18.	° <u>c</u> ≸ 20 0.05 40 0.09 60 0.20 80 0.41	0         5           0         0.015           20         0.02           40         0.05           60         0.13           80         0.30           100         0.65
Ethyl acetate	<u>Carbon</u> tetrachloride	Methanol	Bther	<b>BAPP</b>
° <u>c</u> _ <b>≰</b> 28 2.9 94 18.	<u>°c</u> <u>¥</u> 50 0.005 60 0.007 70 0.009	$\begin{array}{c} \frac{\circ_{C}}{0} & \underline{s} \\ 0 & 0.14 \\ 20 & 0.23 \\ 40 & 0.47 \\ 50 & 1.1 \end{array}$	<u>°c</u> <u>≸</u> 10 0.05 20 0.056 30 0.076	oc         g           80         4.4           85         5.0           90         5.55           95         6.2           100         7.0           105         7.9
lsoanyl alachol	<u>Methyl</u> acstate	A-Sthozyethyl acetate	Chlorobenzene	Trichloro- ethylene
$\begin{array}{c c} & \underline{s} \\ \hline 0 & 0.02 \\ 20 & 0.03 \\ 40 & 0.065 \\ 60 & 0.22 \\ 80 & 0.54 \\ 100 & 1.35 \end{array}$	OC         %           20         2.9           30         3.3           40         4.1           50         5.6	0 <u>c</u> <u>≰</u> 20 0.15 30 0.16 40 0.19 50 0.25	0 <u>0</u> 200 0.33 30 0.44 40 0.56 50 0.74	oc         #           20         0.20           30         0.22           40         0.24           50         0.26
Tetra- chlorcethane	Isopro- panol	Isobutanol.	Chloroform	Mesityloxide
<u>°c</u> <u>≰</u> 38 0.09	<u>°c</u> <u>≰</u> 38 0.18	° <u>c</u> ≰ 20 0.0	<u>°C</u> <u>≰</u> 20 0.01	<u>°C</u> 27 3.2 97 12.2
Cyclo- hexanone	Nitro- benzene	Mitro- ethene	Cyclo- pentanone	cetonitrile
<u>°C</u> <u>≰</u> 25 12.7 97 25	<u>°C</u> <u>\$</u> 25 1.5 97 12.4	<u>°c</u> ≰ 28 3.6 93 19	<u>°c</u> ≰ 28 11.5 90 37	°c ≸ 28 11 82 33
		ethyl ketone		
	ос 28 95	<del>5.6</del> 14		

#### Cyclonite (RDX)

Solubility

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Solubility of Cyclopite, Holston Lot E-2-5 in Various Solvents:

				Solvent	
Solvent	Boiling Point;	Grade or Source	28°0	Heated	Crystalline Form
					WITS GALLING FOTH
Acetone	56	CP CP	8.2	16.5 at 60°C	hexagonal-thick
Cyclohem none	155.6	œ	13.0	24.0 at 93%	cubic (massive form)
Hitromethane	100.8		1.5	12.4 at 97°C	plates
Acetonitrile	81.6	Miacet Chem. Co.	11.3	33.4 at 93°C	plates
1-Hitropropane	126.5	IX Pract	1.4	10.6 at 93°C	short needles
E-MI WORLOOMIN	120	EK Praca	2.3	11.6 at 93°C	short needles
2,4-Pentanedione	140.5	Carbide & Carbon	2.9	18.3 at 93°C	flat prises
Methylisobutylketone	115.8		2.4	9.6 at 93°C	long prisms
n-Propylacetate	101.6	EK Red Label	1.5	6.0 at 93°C	long prisms, some cubic
n-Butylformate	105.6	EK Red Label	1.4	4.6 at 93°C	long priams
Ethyl acetate	77.1	Baker's TP	2.0	6.1 at boil.	hexagonal plates
n-Propylpropionate	121	EK Red Label	0.8	1.6 at 93°C	short prisms, some oubic
Butylacetate	126.5	ET Technicel	1.1	4.0 at 93°C	long prisms
Nethylethylketone	79.6	• (	5.6	13.9 at boil.	coarse plates
Mitroethane	114.2	IK Red Label	3.6	19.5 at 93°C	plates
Isopropylacetate	88-90	CP .	1.1	3.2 at boil.	long prisms
Mesityloxide	128	EX Red Label	4.8	14.5 at 93°C	plates
n-Amylacetate	146	CP	1.0	2.1 at $93^{\circ}$ C	prisme
Dimethylcarbonate	88-91	EX Red Label	1.4	6.6 at boil.	plates
Diethylcerbonate	125-126.5	EK Red Label	0.7	3.2 at 93°C	priems
Isonmylacetate	132	CP .	1.2	3.6 at 93°C	prisms
Ethylpropionate	98-100	KK Red Label	3.0	10.7 at 93°C	fairly thick hex plates
Methyl-n-butyrata	101.5-103.5	EK Red Label	1.2	4.9 at 93°C	needles
Cyclopentanone	130.6	EK Red Label	11.5	39.0 at 93.500	hexagonal plates
Acrylonitrile	77-3	Cyanamid Cc.	4.0	16.4 at boil.	flat plates
Methylcellosolveacetat	e 144.5	Carbide & Carbon	1.6	8.8 at 93°C	massive hexagons and prisms

\* EX, Eastman Kodak; Pract, practical.

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#### Cyclonite (RDX)

Preparation:

(Summary Technical Report of the NDRC, Div 8, Vol 1)

$$(CH_2)_6 H_1 + 4HHO_3 + 2HH_1 NO_3 + 6(CH_3 CO)_2 0$$

Assonium nitrate and acetic anhydride are placed in a flask and, while the mixture is stirred at 75°C, the following three liquids are introduced concurrently and proportionately: acetic anhydride, concentrated nitric acid, and a solution of hexamine in glacial acetic acid. The final mixture is held for a short time at 75°C, diluted with water to 30% acetic acid, and simmered to hydrolyze unstable reaction by-products, which are a mixture of various nitrated and acetylated derivatives of hexamine fragments. After simmering, the slurry is cooled and the precipitated cyclonite removed by filtration. The yield is 78% of the theoretical amount (2 moles) of cyclonite melting at 199°C. By dissolving the ammonium nitrate in the nitric acid, a continuous process, based on 3 liquids, is possible.

The product is recrystallized from acetone, or cyclohexanone, to (a) remove acidity, (b) control particle size and (c) to produce stable *A*-HMX. The preparative procedure described above, the Bachmann or Combination process, yields cyclonite containing 3-8% HMX.

#### Origin:

First prepared by Henning in 1899 (German Patent 104,280) and later by von Hertz (U. S. Patent 1, 402,693) in 1922 who recognized its value as an explosive. Not used on a large scale in explosive ammunition until World War II.

#### Destruction by Chemical Decomposition:

Cyclonite (RDX) is decomposed by adding it slowly to 25 times its weight of boiling 5% sodium hydroxide. Boiling should be continued for one-half hour.

### References: 14

(a) La C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, <u>Part III - Miscellaneous</u> <u>Sensitivity Tests</u>; <u>Performance Tests</u>, <u>OSRD Report No. 5746</u>, 27 December 1945.

- (b) Ph. Maoum, Z. ges Schless Sprengstoffv, pp. 181, 229, 267 (27 June 1932).
- (c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.
- (d) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Second Revision, W/WORD Report No. 37-46, 26 July 1946.

<sup>14</sup>See footnote 1, page 10.

### Cyclonite (RDX)

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(e) Arsement Research Department (Woolwich), Solubility of RDX in Mitric Acid (ARD Expl Rpt 322/43 September 1943).

(f) Report AC-2587.

(g) <u>International Critical Tables</u> Land. Bornst.

B. T. Fedoroff et al, <u>A Manual for Explosives Laboratories</u>, Lefax Society Inc, Philadelphia, 1943-6.

(h) B. Hutchinson, <u>The Therrel Pansitiveness of Explosives</u>. The Thermal Conductivity of <u>Explosive Materials</u>, AC 2001, First Report, August 1942.

(i) R. J. Finkelstein and G. Gamow, Theory of the Detonation Process, NAVORD Report No. 90-46, 20 April 1947.

(j) International Critical Tables.

(k) W. F. McGarry and T. W. Stevens, Detonation Rates of the More Important Military Explosives at Several Different Temperatures, PATR No. 2383, November 1956.

(1) Also see the following Picatinny Arsenal Technical Reports on Cyclonite:

<u>o</u>	<u>1</u>	2	3	<u>4.</u>	2	<u>6</u>	I	<u>8</u>	2
1170 1290 1360 1450 1760 1980 2100	1211 1241 1311 1421 1481 1561 1651 1651 1741 1751 1761 2131 2151	582 1342 1352 1352 1402 1452 1492 1532 2062 2112	863 1193 1293 1433 1483 1503 1713 1793 1923	1184 1414 1454 1614 1634 2024 2154 2204	65 1175 1185 1435 1445 1715 1855 1855 1855 1915 1935 2095 2125 2205	1236 1316 1416 1446 1476 1556 1756 1756 1756 1756 1756 1936 2056 2056 2056 2176	857 1207 1427 1517 1617 1617 1617 1737 1747 1787 1797 1957 2147 2227	1438 1498 1578 1838 1958 2008 2028 2178 2198	709 1379 1429 1449 1469 1709 2059 2179

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### Cyclotol, 75/25

Composition:	Molocular Weight:	224
%		
RDX 75	Oxygen Belance: CO <sub>2</sub> %	-35
	co %	- 6
1NT 25	Danity: gm/cc Cast	1.71
· · · · · · · · · · · · · · · · · · ·	Maiting Paint: *C	
C/H Rotio	Freezing Puint: *C	
Impact Sensitivity, 2 Kg Wt:	Briding Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	Refractive Index, ng	
Picatinny Arsenal Apparatus, in.	nh	
Sample Wt, mg	2.	
Friction Pandalan Test:	Veccum Stability Test:	
5 eel Shoe Unaffected	cc/40 Hrs, at 90°C	
Fiber Shoe Unaffected		0.23
Rifle Bullet Impact Test: Trials	120°C	0.41
- %	135°C	-
Expissions 30	150*C	
Partials Smokes 40		
Burned 0	200 Grem Bomb Sond Test:	
Unoffected 30	Sand, gm	
Explosion Temperature: °C	Sensitivity to Initiation:	
Seconds, 0.1 (no unp used)	Minimum Detonating Charge,	gm
1	Mercury Fulminate	
5	Lead Azide	
10	Tatryl	
15 20	Ballistic Morter, % TNT:	
	Trousi Toot, % TNT:	
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Test: Method	
	Canditian	
100°G Host Test:	Confined	
% Loss, 1st 48 Hrs	Density, gm/cc	
% Loss, 2nd 48 Hrs	Brisance, % TNT	
Explosion in 100 Hrs		
Fiermability Index:	Confinement None	None
	Contraction	
Hygreecepicity: %	Condition Cast	
	Charge Diameter, in. 1.0 Density am/cc 1.70	1.0 1.71
Veletility:		
•	Rate, meters/second 8035	1930

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### Cyclotol, 75/25

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Beester Sensitivity Test: Condition		Decomposition Equation: Oxygen, atoms/sec
Tatryl, gm		(Z/sec)
Wax, in. for 50% Detonation		Heat, kilocolorie/mole
Wax, gm		(ΔH, kcal/mol)
		Temperature Range, °C
Density, gm/cc		Phose
Hest of:	060cz	Armor Plate Impect Test:
Combustion, col/gm	2625*	
Explosion, col/gm	1225*	60 mm Martar Projectile:
Gas Volume, cc/gm	862	50% Inert, Velocity, ft/sec
Formation, col/gm		Aluminum Fineness
Fusion, col/gm (h)	5.0	
Calculated from composition of m	IIture.	500-15 General Parpese Sombe:
Specific Hust: col/gm/*C (h)		Plate Thickness, inches
-75 0.220 75 0.352 0 0.225 85 0.325		
<b>25 0.25</b> 4 90 0.32		11/4
50 0.296 100 0.351		11/2
Berning Rote:	<del></del>	1%
cm/sec		Somb Drop Test:
Thermal Conductivity: cal/sec/cm/*C		17, 2000-16 Semi-Armer-Piercing Bemb vs Concrete:
Coefficient of Expension:		Max Safe Drop, ft
Lineor, %/*C		500-16 General Purpose Bamb vs Concrete:
Volume, %/*C		
		Height, ft
Hardness, Mahe' Scale:		Trials -
		Unaffected
Young's Modulus:		Low Order
E', dynes/cm <sup>2</sup>		High Order
E, Ib/inch <sup>a</sup>		
Density, gm/cc		1000-16 General Purpose Bomb vs Concretu:
Compressive Strength: Ib/inch <sup>2</sup>		Height, ft
		Trials
_		Unoffected
Veper Pressure:		Low Orde:
*C mm Mercury		High Order

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· Constant

### Cyclotol, 75/25

Fregmentation Test:		Shaper Charge Effecti	veness, TNT = 10	0:
90 mm HE, M71 Projectile, Le	WC-91:	Gloss	Cones Steel Co	ones .
Density, gm/cc	1.72	Hole Volume		
Charge Wt, Ib	2.22	Hole Depth		
Charge Wr, Io	£+£6	noie Cepin		
Total No. of Fragments:		Celer:		
For TNT	703		Yellow-buff	
For Subject HE	1514			
3 inch HE, M42A1 Projectile, L			ped charge bom gmentation; HE	
		dre dre	nades	• •
Density, gm/cc	•			
Charge Wt, Ib				
Total No. of Fragments:		Method of Londing:		Cast
For TNT		_		•
For Subject HE				
		Loading Density: gm/c	×	1.71
Fragment Velocity: ft/sec				
At 9 ft				·
At 251/2 ft		Storage:		
Density, gm/cc				
		Method		Dry
Blast (Relative to TNT):	(a)	Hazard Class (Quan	itity-Distance)	Class 9
Air:		Compatibility Group	•	Group I
Peak Price (re	111	1		
Impuise	126	Erudation		
Energy				
		Preparation: See C	omosition B	
Air, Confined:				•
impulse		Origin: Developed		
· · · · · · · · · · · · · · · · · · ·		Wars I and II a States early in		a in the United
Under Water:		-		
Peak Pressure		Black Modulus at R	0000	
Impulse		Temperature (25°-3		
Energy	,	Dynes/cm <sup>2</sup> x 10 <sup>-</sup>	10 -	3.09
Chargy		Density, gm/cc		1.74
Underground:		Absolute Viscosity	, poises:*	
Peak Pressure		Temp, 85 C		210**
		90°C		
Impukts		Efflux Viscosity,	Saybolt Second	B:
Energy		Temp, 85°C		9-14
		, , , , , , , , , , , , , , , , , , ,		7-14
		* Compositions using	ng Shec Green '	Done A
		Class A RDX.	D ober ange	- J P C N J
		** Composition prep	ared using RDX	of optimum
		particle size.		

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Molecular Weight:	224
Oxygen Belence:	
CO. %	-37 - 8
CO %	• 0
Density: gm/cc Cast	1.71
Molting Point: 'C	
Freezing Point: "C	
Boiling Point: "C	
Refrective Index. nº	
n <u>s</u>	
Vocuum Stability Test:	
cc/40 Hrs, at	
90°C	
100°C	- 04
	0.86
150°C	
200 Grem Bomb Sand Test:	
Sand, gm	56.6
Sensitivity to Initiation:	·····
Minimum Detonating Charge, gr	m
Mercury Fulminate	0.21*
Leod Azide	0.20*
Tetryl	
	135
Plate Dent Test: (b)	-
	В
	Cast
	No
	1.725
Brisance, % TNT	136
Detonation Rate:	
	None
	Cast
Charge Diameter, in.	1.0
Density, gm/cc	1.73
	Oxygen Belence: CO. % CO %         Density: gm/cc       Cast         Making Point: 'C         Freezing Point: 'C         Beiling Point: 'C         Refrective Index, ng, ng, ng, ng, ng, ng, ng, ng, ng, ng,

Cyclotol, 70/30

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### Cyclotol, 70/30

Fregmenistion Test:		Shoped Charge Effectiveness, TNT ==	100:
90 mm HE, M72 Projectile, Lot '	WC-91:	Gloss Cones Stee	I Cones (e)
Density, gm/cc	1.71	Hole Volume	
Charge Wt, Ib	2.213	Hole Depth	130
Total No. of Fragments:		Color: Y	ellow-buff
For TNT	703		
For Subject HE	1165		
3 inch HE, M42A1 Projectile, Lat	KC-S:	Principal Uses: Shaped charge be especially frage	
Density, gm/cc	1.72	projectiles, gro	enades
Charge Wt, It	0.923		
Charge Wr, ic	0.7-3		
Total No. of Fragmonts:			
For TNT	514	Method of Looding:	Casi
For Subject HE	828		
	020	Loading Density: gm/cc	1.71
Reason Valasha fa (san			
Fregment Velocity: ft/sec At 9 ft			
At 251/2 ft		-Sterage:	
Density, gm/cc			-
		Method	Dry
			Class 9
Blast (Relative to TNT):	(d)	Hazard Class (Quantity-Distance)	
Air:		Compatibility Group	Group I
Peok Pressure	110		
impulse	120	Exudation	
Energy			
and the St			
Air, Confired:		Preparation: See Composition	
Impulse		Origin: Developed by the Brit	
		World Wars I and II and st the United States early in	
Under Weter: Peak Pressure		Absolute Viscosity, poises:*	
		Temp, 85°C	
Impulse		90°C	53.2
Energy		Efflux Viscosity, Saybolt Sec	onda:
Underground:		Temp, 85°C	5
Peak Pressure			**
Impulse		Heat of:	
Energy		Combustion, cal/gm Explosion, cal/gm	2685 1213
		Gas Volume, cc/gm	854
×			-
		* Composition using Spec Grad	е Туре А,
		Class A RDX. ** Calculated from position	of mixture.
		alculated if 90810100	OI MIXVAIC!

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Cyclotol, 65/35

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Composition:	Melecular Weight:	224
% RDX 55	Oxygen Belence:	
KLAR CJ	CO <sub>2</sub> %	-40
<b>TNT</b> 35	CO %	- 9
	Density: gm/cc Cast	1.71
	Molting Point: "C	
C/H Ratio	Freezing Point: *C	
Import Sensitivity, 2 Kg Wt:	Beiling Point: *C	
Bureau of Mine: . Aparatus, cm Sample Wt 20 mg	Refrective Index, ng	
Picatinny Arsenal Apparatus, in.	ng	
Sample Wt. mg		
	n20	
Friction Pondulum Test:	Vecuum Stability Test:	
Steel Shoe Unaffected	cc/40 Hrs, at	
Fiber Shoe Unaffected	90°C	
Rifle Builet Impact Test: Trials	100°C	
	120°C	
% Sectors	135°C	
Partials	150°C	
Burned	200 Grem Bemb Send Teet:	
Unoffected	Sand, gm	55.4
Explosion Te. sporature: "C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gr	n
1 5 December 270	Mercury Fulminate	
5 Decomposes 270	Leod Azide	
10	Tetryi	
15	Bellistic Morter, % TNT: (a)	134
20	Treast Test, % TNT:	<b></b>
75°C International Heat Test:		
% Loss in 48 Hrs	Plate Dent Test: Method	
	Condition	
100°C Hest Test:	Confined	
% Loss, 1st 48 Hrs	Density, gm/cc	
% Loss, 2nd 48 Hrs	Brisonce, % TNT	
Explosion in 100 Hrs		
	Detenation Rate:	
Flammability Index:	Confinement	None
	Condition	Cast
Hygrescapicity: % Nil	Charge Diameter, in.	1.0
	Density, gm/cc	1.72
Velatility: N11		7475

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#### Cyclotol, 65/35

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Fragmentation Test:		Shaped Charge Effectiveness, TNT = 1	1 <b>80:</b>
99 mm HE, M71 Projectile, Let WC		Glass Cones Steel	Cones (e)
Density, gm/cc	1.71	Hole Valume	
Chorge Wt, ib	2.253	Hole Depth 130	)
Total No. of Progmants:		Color: Yoldan bu	
For TNT	703	Yellow-bu	uff [
For Subject HE	1153	Principal Seas: Shaped charge box	ibs:
3 inch Hil, M42A1 Projectile, Let KC	-5:	especially freque projectiles, grea	ntation HE
Density, gm/cc	1.71	projectiies, gree	mues .
Charge Wt, Ib	0.922		
Total No. of Fragments:		Method of Londing:	Cast
For TNT For Subject HE	514 769		
		Looding Density: gn/cc	1.71
Program Valacky: ft/sec At 9 ft At 2516 ft		Storage:	
		See alia:	
Density, gm/cc		Method	Dry
Blast (Relative to THT):		Hazard Class (Quantity-Distance)	Class 9
Air: Peak Pressure		Compatibility Group	Group I
Impulse		Exudation	
•			1
Energy		Preparation: See Composition B	
Air, Confined:			1
impulse Under Water:		Origin: Developed by the Britis World Wars I and II and stand the United States early in Wo	ardized in
Peak Pressure	i	But at a manual and Pa	-
Impulse		Eutectic Temperature, °C:	79
Energy		gm RDX/100 gm TNT 79 <sup>0</sup> C	4.16
Underground:		95°C	5.85
Peak Pressure		Absolute Viscosity, poises:*	
Impulse			
Energy		Temp, 85°C 90°C	30.2 26.0
Heat of:	*	* Composition using Spec Grade	Type A.
Combustion, cal/gm	2755	Class A RDX.	
Explosion, cal/gm	1205		
Ges Volume, cc/gm * Calculated from composition	845 of mixture.		

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Cyclotol, 60/40 C Molocular Weight: 224 % Correction RDX 60 -43 10 THT 40 Density: gm/cc Cast 1.68 Molting Point: °C C/H Ratio Freezing Point: \*C npest Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm Sample Wt 20 mg Picctirmy Arsenal Apparatus, in. Sample Wt, mg Boiling Point: \*C **7**5 Refrective Index, no 14 **N**25 19 fi<sub>30</sub> **Friction Pandulum Test:** Vocum Stability Test: Steel Shoe Unaffected cc/40 Hrs, ot Fiber Shoe Unaffected 90°C 100°C Zifle Bullet Impact Test: Trials 120°C 0.29 **%** 5 135°C Explosions 150°C **Porticils** 55 Burned 25 200 Grem Bomb Send Test: Unaffected 15 Sand, gm 54.6 Explosion Temperature: Sonsitivity to Initiation: •C Seconds, 0.1 (no cap used) Minimum Detonating Charge, gm **Mercury Fulminate** 0.22\* 1 5 Decomposes 280 Leod Azide 0.20\* 10 Terryl \*Alternative initiating charges. 15 20 Bellistic Morter, % TNT: (a) 1.33 Treuzi Test, % TNT: 75°C International Heat Test: Plate Dent Test: (b) % Lose in 48 Hrs Method В Condition Cast 100°C Heat Test: Confined No % Loss, 1st 48 Hrs 1.72 Density, gm/cc % Loss, 2nd 48 Hrs Brisonce, % TNT 132 Explosion in 100 Hrs nation Rate: Date Flammability Index: Confinement None Condition Cast Hyproscopicity: % Nil Charge Diameter, in. 1.0 Density, gm/cc 1.72 Veletility: Nil Rote, meters/second

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AMCP 706-177

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### AMCP 706-177

### Cyrlotol, 60/40

99 men HE, MJT Projectile, Let WC-91: Density, gm/cc       1.65 Chorge WT, 16       Cleas Cones Steel Cones (e)         Tetel Me, of Progenents: For TNT       703 For Subject HE       998         3 lack ME, M42A1 Projectile, Let KC-5: Density, gm/cc       Caler: 1.67 Chorge WT, 16       Yellow-buff         Tetel Me, of Fregmenent: For TNT       703 For Subject HE       Shaped charge boxb; especially Tragmentation HE projectiles, grenades         Tetel Me, of Fregmenent: For TNT       514 For Subject HE       Mathed of Leading: Cast         Fregmenet Velocity: ft/sc: Peek Pressure       (c) At 9 ft A 25 ft At	fregmentation Test:		Shaped Charge Effectiveness, TNT =	190:
Charge Wr, 16     2.187       Tetel Na. of Fregments:     For TNT       For TNT     703       For Subject HE     998       3 lack HE, M42A1 Projectile, Let KC-3:     Density, gm/cc       Density, gm/cc     1.67       Charge Wr, 1b     0.382       Tetel Na. of Fregments:     For TNT       For TNT     514       For Subject HE     701       Fregment Velocity: fr/sec     (c)       Atr:     2965       Peet Relative to TNT):     (d)       Atr:     Pregment 1004       Impulse     116       Energy        Atr:     Pregmentic:       Peek Presure     104       Impulse     116       Energy        Marked Weer:     Pregmentic:       Peek Presure     104       Impulse     116       Energy        Marked States early in World Wer II.       Peek Presure     104       Impulse     116       Energy        Marked of States early in World Wer II.       Peek Presure     109701       Impulse     1195       Energy        Peek Presure     1990°C       Impulse     195       <	90 mm HE, M71 Projectile, Let	WC-91:	Glass Cones Steel	Cones (a)
Charge WI, B       2.187         Teed Na. of Prognessits:       For TNT         For TNT       703         For Subject HE       998         3 lack ME, M42A1 Projectile, Lot KC-5:       Density, gm/cc         Density, gm/cc       1.67         Charge WI, b       0.382         Tetel Na. of Frequencit:       For TNT         For Subject HE       701         Frequencity: fn/sec       (c)         At 9 4       255         At 25½ ft       2800         Density, gm/cc          Mathod       Dry         Hole Depth       125         Image: He 201       Calar:         Yesplaced:       16         Frequencit:       Preparation: See Composition B         Origin: Developed by the British between World Wer I and standardized in the United States early in World Wer II.         Mack Weer:       Presure         Impulse       104         Impulse       116         Energy          Mack Office Weer:       Presore         Presore       104         Impulse       Under Weer:         Presore       104         Density, gm/cc       1.72	Density, gm/cc	1.65	Hole Volume 178	162
For TNT       703         For Subject HE       998         3 lack HE, MABA1 Projectile, Let KC-3:       Principal Uses         Density, gm/cc       1.67         Charge Wt, Ib       0.882         Tetel Ne. of Fregments:       For TNT         For Subject HE       701         Fregment Valuely: fr/sec       (c)         At 7 9 ft       2965         At 25% ft       2900         Density, gm/cc          Method of Leading:       Cast         Fregment Valuely: fr/sec       (c)         At 25% ft       2900         Density, gm/cc          Method       Dry         Hazord Class (Quantity-Distonce)       Class 9         Compatibility Group       Group I         Energy          Atr:       Preparation:         Peek Pressure       104         Impulse       Ind         Impulse       116         Energy          Vides Wete::       Preparation:         Peek Pressure       104         Impulse       Dilk Modulus at Roon         Impulse       Energy         Prek Pressure       101	•••	2.187	Hole Depth 125	148
For TNT       703         For Subject HE       998         3 lack HE, M42A1 Projectile, Let KC-5:       empecially fragmentation HE         Density, gm/cc       1.67         Charge Wt, Hb       0.882         Tetel Ne. of Fragments:       For TNT         For Subject HE       701         Freegenet Velocity: fr/sec       (c)         AP 4ft       2860         Density, gm/cc          Method of Leading:       Cast         Freegenet Velocity: fr/sec       (c)         AP 4ft       2860         Density, gm/cc          Method       Dry         Hozard Class (Quantity-Distance)       Class 9         Compatibility Group       Group I         House Early          Abr:       Peak Pressure         Impulse       116         Energy          Viedser Weter:       Peak Pressure         Peak Pressure       104         Impulse       Drigin: Developed by the British between         World Weter:       Pregenerature (259-30°C):         Peak Pressure       Dulk Modulus at Room         Impulse       Energy         Dinest Of:       *	Total No. of Fragments:		Color: Yel:	Low-buff
3 inch HE, MADA 1 Projectile, Let KC-S:         Density, gm/cc       1.67         Chonge Wt, Ib       0.882         Tetel Ne. of Fregmentation IE         For TNT       51Å         For Subject HE       701         Present Velocity: fr/sec       (c)         At 25% ft       2800         Density, gm/cc          Method of Leading:       Cast         Fregment Velocity: fr/sec       (c)         At 25% ft       2800         Density, gm/cc          Method       Dry         Bleet (Balative to TNT):       (d)         Alr:       Preparation: See Composition B         Impulse       116         Energy          Alr, Cenfined:       mpulse         Impulse       116         Energy          Velack Weter:       Impulse         Pack Pressure       10Å         Impulse       Built Modulus at Room         Energy          Velack-pressure       10%         Impulse       110%         Energy          Velack-pressure       10%         Impulse	For TNT	703		
3 inch ME, MARA1 Projectile, Let RC-S:       projectiles, grenades         Density, gn/cc       1.67         Charge Wt, Hb       0.882         Tetel Ne. of Pregnenets:       Mathed of Leading:         For TNT       514         For Subject HE       701         Image: State St	For Subject HE	998	Principal Uses: Shaped charge be	omab;
Charge Wt, Ib     0.382       Tetel No. of Frequencits: For TNT     514       For Subject HE     701       Frequencit Velocity: fr/sec At 25% ft     2800       Density, gm/cc        Baset (Raletive to TNT):     (d)       Akr: Peak Pressure     104       Impuise     116       Energy        Akr, Confided: Impuise     106       Impuise     116       Under Weter: Peak Pressure     104       Impuise     116       Under Weter: Peak Pressure     104       Impuise     116       Energy        Values Veter: Peak Pressure     104       Impuise     116       Energy        Values Veter: Peak Pressure     104       Impuise     116       Energy        Under Weter: Peak Pressure     104       Impuise     115       Density, gm/cc     1.72       Absolute Viscosity, poisees:*     1.72       Peak Pressure     1.72       Impuise     290°C       Energy     *       irest off:     2820       Explositor, csl/gm     2820       Explositor, csl/gm     2820       Explositor, csl/gm     1195	3 inch HE, M42A1 Projectile, Lo	t KC-S:		
Tetel No. of Frequents:       For TNT       514         For Subject HE       701       Leeding Density: gm/cc       1.68         Frequent Velocity: tr/sec       (c)       At 9 ft       2965         At 9 ft       2965       Storage:       Density: gm/cc       1.68         Density, gm/cc        Method       Dry         Bleet (Reletive to TNT):       (d)       Herord Closs (Quantity-Distance)       Class 9         Alr:       Peak Pressure       104       Exaddian       Energy         Impulse       116       Exaddian       Energy          Alr: Confined:       Impulse       116       Exaddian       Energy       Group I         Under Weter:       Peak Pressure       104       Bulk Modulus at Room       Temprature (250-30°C):       Energy         Usdesgreend:       Preparetion:       See Composition B       Temprature (250-30°C):       Density, gm/cc       1.72         Usdesgreend:       Peak Pressure       Impulse       Energy       Temprature (250-30°C):       Energy       1.72         Usdesgreend:       Prestore       Impulse       Temprature (250-30°C):       Energy       1.72         Density, gm/cc       1.72       Mesolute Viscosity, poises:*	Density, gm/cc			
For TNT       514         For Subject HE       701         Fregment Velocity: ft/sec       (c)         AP 9 ft       2965         At 25½ ft       2800         Density, gm/cc          Method       Dry         Bloot (Balative to TNT):       (d)         Alr:       Peak Pressure         Impulse       116         Energy          Alr, Centised:       Impulse         Impulse       116         Energy          Vider Weter:       Preparation:         Peak Pressure       104         Under Weter:       Preparation:         Impulse       116         Energy          Vider Weter:       Preparation:         Impulse       Drigin: Developed by the British between         World Wers I and II and standardized in the United States early in World War II.         Bulk Modulus at Room       Temperature (250-30°C):         Impulse       Drynes/cm <sup>2</sup> x 10 <sup>-10</sup> 4.14         Density, gm/cc       1.72         Absolute Viscosity, poises:*       Temp, 85°C       12.3         jiest of;       *       Compositions using Spec Grade Type A, Class A RDX.	Charge Wt, Ib	0.882		
For Subject HE     701       Frequencet Velocity: it/sec     (c)       At 9 ft     2965       At 25½ ft     2800       Density, gm/cc        Method     Dry       Bleet (Relative to TNT):     (d)       Als:        Pack, Pressure     104       Impulse     116       Erargy        Als:        Pack, Pressure     104       Impulse     116       Erargy        Als:        Peak, Pressure     104       Impulse     116       Erargy        Veder Weter:        Peak Pressure     104       Impulse        Impulse        Impulse        Impulse        Impulse        Impulse        Impulse        Impulse        Impulse        Pack Pressure        Impulse        Pack Pressure        Impulse        Pressore        Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> 4.14       Density, gm/cc     1.72   <	Total No. of Fragmonts:		Method of Looding:	Cast
Freegment Velocity: fr/sec       (c)         At 9 ft       2965         At 25½ ft       2800         Density, gm/cc          Bleet (Relative to TNT):       (d)         Alr:       Peak Pressure         Peak Pressure       104         Impulse       116         Energy          Als:       Preparation: See Composition B         Origin: Developed by the British between         World Ware I and II and standardized in         the United States early in World War II.         Bulk Modulus at Room         Impulse         Energy         Peak Pressure         Impulse         Energy         Peak Pressure         Impulse         Energy         Peak Pressure         Impulse         Energy         Peak Pressure         Impulse	For TNT	514		
Frequence Velocity: ft/sec       (c)         At 9 ft       2965         At 25½ ft       2800         Density, gm/cc          Bleet (Reletive to TNT):       (d)         Akr:       Peak Pressure         Peak Pressure       104         Impulse       116         Energy          Akr.       Preparation: See Composition B         Origin: Developed by the British between         MortId Ware I and II and standardized in         Impulse       Inthe United States early in World War II.         Bulk Modulus at Room         Temperature (250-30°C):         Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> 4.14         Density, gm/cc       1.72         Absolute Viscosity, poises:*         Temp, 85°C       12.3         Prest of:       2820         Energy       *         Origins, cal/gm       1195         Basic of:       20% C	For Subject HE	701	Leading Density: om/cc	1.68
At 9 ft       2065         Ar 25½ ft       2800         Density, gm/cc          Bloof (Reletive to TNT):       (d)         Ak::       Peak Pressure         Peak Pressure       104         Impuise       116         Energy          Ak; Confined:       Preparation:         Impuise       116         Under Weter:       Preparation:         Peak Pressure       104         Impuise       0rigin: Developed by the British between         World Weter:       World Wers I and II and standardized in         Impulse       Bulk Modulus at Room         Impulse       Bulk Modulus at Room         Impulse       Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> 4.14         Density, gm/cc       1.72         Absolute Viscosity, poises:*       Temp, 85°C       12.3         instion, cs1/gm       2820          *       *       Compositions using Spec Grade Type A, Class A RDX.	Fromment Velocity: ft/sec	(c)		1.00
Method     Dry       Blact (Relative to TNT):     (d)     Hozard Class (Quantity-Distance)     Class 9       Akr:     Peak Pressure     104       Impulse     116     Exudation       Energy      Preparation: See Composition B       Akr. Confined:     Impulse       Impulse     0rigin: Developed by the British between       Vector:     Peak Pressure       Impulse     0rigin: Developed by the British between       World Water:     Peak Pressure       Impulse     Bulk Modulus at Room       Impulse     Bulk Modulus at Room       Impulse     Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> Impulse     Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> Impulse     Temp, 85°C       Impulse     2820       Proposition, cal/gm     1195       Gas Volume, cc/gm     845	At 9 ft	2965	Storage:	
Air:       Compatibility Group       Group I         Peak Pressure       104         Impulse       116         Energy          Air, Cestimed:       Impulse         Impulse          Dider Weter:       Preparation:         Peak Pressure       Origin: Developed by the British between World Wars I and II and standardized in the United States early in World War II.         Under Weter:       Peak Pressure         Impulse       Energy         Energy       Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> Underground:       4.14         Density, gm/cc       1.72         Absolute Viscosity, poises:*       Temp, 85°C         Temp, 85°C       12.3         g0°C          *       Compositions using Spec Grede Type A, Class A RDX.	Density, gm/cc		Method	Dry
Peak Pressure104Impuise116EnergyAir, Confined: ImpuiseImpuiseUnder Weter: Peak Pressure ImpuiseUnder Weter: Peak Pressure ImpuiseUnder Weter: Peak Pressure ImpuiseDrigin: Developed by the British between World Wars I and II and standardized in the United States early in World War II.Under Weter: Peak Pressure ImpuiseDrigin: Developed by the British between World Wars I and II and standardized in the United States early in World War II.Uaderground: Peak Pressure ImpuiseBulk Modulus at Room Temperature (25°-30°C): Dynes/cm² x 10°10Uaderground: Peak Pressure ImpuiseDynes/cm² x 10°10 4.14 Density, gm/ccUaderground: Peak Pressure Impuise4.14 Density, gm/ccUnder World: Peak Pressure Impuise*Compustion, cal/gm Explosion, cal/gm Gas Volume, cc/gm2820 845* Compositions using Spec Crade Type A, Class A RDX.	Blast (Relative to TNT):	(ð)	Hazard Class (Quantity-Distance)	Ciass 9
Peak Pressure104Impuise116EnergyAir, Centioned: ImpuiseJunder Weter: Prock PressureUnder Weter: ImpuiseUnder Weter: Prok PressureUnder Weter: ImpuiseUnder Weter: Prok PressureUnder Weter: ImpuiseUnder Weter: Prok PressureUnder Weter: ImpuiseUnderground: ImpuiseDiscond PressureImpuiseEnergyDynes/cm2 x 10 <sup>-10</sup> 4.14Density, gm/cc1.72Pook PressureImpuiseEnergyDynes/cm2 x 10 <sup>-10</sup> 4.14Density, gm/cc1.72Pook PressureImpuiseEnergyPool Pression, cal/gm2820Explosion, cal/gm1195Gas Volume, cc/gm845Compositions using Spec Crade Type A, Class A RDX.	<b>AL:</b>		Compatibility Group	Group I
ImpulseIfErergyAir, Cenfined: ImpulseImpulseUnder Weter: Peok Pressure ImpulseOrigin: Developed by the British between World Wars I and II and standardized in the United States early in World War II.Bulk Modulus at Room Temperature (25°-30°C): Dynes/cm² x 10 <sup>-10</sup> 4.14 Density, gm/ccUnderground: ImpulseDynes/cm² x 10 <sup>-10</sup> 4.14 Density, gm/ccImpulse Erergy*Impulse Erergy*Impulse Erergy*Impulse Erergy*Combustion, cal/gm Explosion, cal/gm Gas Volume, cc/gm2820 845		104		
Air, Confined: ImpulsePreparation: See Composition BUnder Water: Peok Pressure ImpulseOrigin: Developed by the British between World Wars I and II and standardized in the United States early in World War II.Under Water: Peok Pressure ImpulseBulk Modulus at Room Temperature (25°-30°C): Dynes/cm² x 10 <sup>-10</sup> Underground: Peok Pressure ImpulseDynes/cm² x 10 <sup>-10</sup> Underground: Peok Pressure ImpulseDynes/cm² x 10 <sup>-10</sup> Underground: Peok Pressure ImpulseAbsolute Viscosity, poises:*Temp, 85°C 90°C12.3 90°CDynes/cm² x 10'1195 Gas Volute, cc/zmSas Volute, cc/zm845	Impuise	116	Exudation	
Air, Continued: ImpulseOrigin: Developed by the British between World Wars I and II and standardized in the United States early in World War II.Under Weter: Peok Pressure Impulse EnergyDrigin: Developed by the British between World Wars I and II and standardized in the United States early in World War II.Under Weter: Peok Pressure Impulse EnergyBulk Modulus at Room Temperature (25°-30°C): Dynes/cm² x 10 <sup>-10</sup> 4.14 Density, gm/ccUnderground: Peok Pressure Impulse EnergyDynes/cm² x 10 <sup>-10</sup> 4.14 Density, gm/ccUnderground: Peok Pressure Impulse Energy* 1.72 Pool Pressure Dynes/cm² x 10 <sup>-10</sup> 4.14 Density, gm/ccUnderground: Peok Pressure Impulse Energy* 2820 Peok Pressure Impulse Energy* Compositions using Spec Grade Type A, Class A RDX-	_ •	••		
Under Weter: Peok PressureOffgin: Percepted by the fitness between World Wars I and II and standardized in the United States early in World War II.Peok Pressure ImpulseBulk Modulus at Room Temperature (25°-30°C):Dynes/cm2 x 10 <sup>-10</sup> 4.14 Density, gm/ccUnderground: Peok PressureDynes/cm2 x 10 <sup>-10</sup> ImpulseAbsolute Viscosity, poises:*EnergyTemp, 85°CJiest of: Combustion, cal/gm2820 1195 Gas Volume, cc/gm* Compositions using Spec Grade Type A, Class A RDX.	-		Preparation: See Composition	В
Peak Pressure impulseBulk Modulus at Room Temperature (25°-30°C):EnergyDynes/cm² x 10 <sup>-10</sup> Underground: Peak Pressure impulseDynes/cm² x 10 <sup>-10</sup> Underground: Peak PressureDynes/cm² x 10 <sup>-10</sup> Underground: Peak PressureAbsolute Viscosity, poises:*ImpulseTemp, 85°CEnergy Dombustion, cal/gm2820Explosion, cal/gm1195Gas Volume, cc/gm845	•		World Wars I and II and sta	ndardized in
ImpulseTemperature (25°-30°C):EnergyDynes/cm² x 10 <sup>-10</sup> Underground:Dynes/cm² x 10 <sup>-10</sup> Peak PressureDynes/cm² x 10 <sup>-10</sup> ImpulseDynes/cm² x 10 <sup>-10</sup> EnergyAbsolute Viscosity, poises:*Temp, 85°C12.3Mest of:*Combustion, cal/gm2820Explosion, cal/gm1195Gas Volume, cc/gm845	• • • • • • • • • • • • • • • • • • • •		•	nella nel 11.
Energy       Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> 4.14         Underground:       Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> 4.14         Density, gm/cc       1.72         Peak Pressure       Absolute Viscosity, poises:*         Impulse       Temp, 85°C       12.3         Diest of:       *       90°C          Combustion, cal/gm       1195       * Compositions using Spec Grade Type A, Class A RDX.	impulse			
Underground:       Density, gm/cc       1.72         Peak Presture       Absolute Viscosity, poises:*         Impulse       Temp, 85°C       12.3         Biest of:       *       90°C          Combustion, csl/gm       2820       *       Compositions using Spec Grade Type A, Class A RDX-	Energy			հոհ
ImpulseAbsolute Viscosity, poises:*EnergyTemp, 85°Cliest of:*Combustion, cal/gm2820Explosion, cal/gm1195Gas Volume, cc/gm845				
EnergyTemp, 85°C12.3liest of:*90°CCombustion, cal/gm2820*Compositions using Spec Grade Type A, Class A RDX-			Absolute Viscosity, poises:*	
Hest of:     *     Hemp, 90°C       Combustion, cal/gm     2820       Explosion, cal/gm     1195       Gas Volume, cc/gm     845	•			
Combustion, cal/gm 2820 Explosion, cal/gm 1195 Gas Volume, cc/gm 845 Class A RDX-	•	* 、	Temp, 35°C	12.3
Explosion, cal/gm 1195 Gas Volume, cc/gm 845 Compositions using Spec Grade Type A, Class A RDX-		<b>T</b>	90-0	
	Explosion, cal/gm	1195		e Type A,
Compressive Strength: Le/inch 1.70 m/cc 2200-3000	Compressive Strength: 1b/i	nch <sup>2</sup>		

Calculated from composition of mixture.

### Grelotol, 75/25, 70/30, 65/35

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### References: 15

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(a) L. C. Smith and E. G. Ryster, <u>Physical Testing of Explosives</u>, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OCRD Report No. 5745, 27 December 1945.

(b) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(c) R. W. Drake, <u>Pregment Velocity and Panel Penetration of Several Explosives in Simulated Shells</u>, OSRD Report No. 5622, 2 January 1946.

(d) V. Philipchuk, <u>Pres Air Blast Evaluation of ADX-THT-Al, RDX-THT, and THT-Metal Systems</u>, Mational Northern Summary Report, NN-P-34, April 1956.

(e) Hastern Laboratory, du Pont, <u>Investigation of Cavity Effect. Section III, Variation of</u> <u>Cavity Effect with Composition</u>, NERC Contract W-672-ORD-5723.

(f) W. S. Cramer, Bulk Compressibility Data on Several High Explosives, NAVORD Report No. 4360, 15 September 1956.

(g) Also see the following Picatinny Arsenal Technical Reports on Cyclotols:

0	1	2	3	4	٤	<u>6</u>	I	8	2
1290 1530	1651 1741	1482	1483 1793 19°3	1824 1834 1944 2004	1435 1585	1476 1756 1796 1876	1427 1507 1747	1398 1488 1838	1469 1509 1709

(h) C. Lenchitz, W. Beach and R. Valicky, Enthalpy Changes, Heat of Fusion and Specific Heat of Basic Explosives, PATR No. 2504, January 1959.

15See footnote 1, page 10.

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### Cyclotrimethylene Trinitrosamine

Composition: H % 12		Melecular Weight: (C3H6N603)	174
c 20.6		Oxygen Belunce:	
H 3.5 0-N-N	N-N-0	CO % CO %	-55 -26
H 48.3 H <sub>2</sub> C	- сн <sub>о</sub>	Density: gm/cc	
0 27.6	- °°2	Mahing Point: *C	105 to 107
C/H Ratio 0.12		Freezing Point: "C	
Impost Sensitivity, 2 Ke Wt:	· · · · ·	Boiling Point: *C	
Bureau of Mines Apparatus, cm			
Sample Wt 20 mg Picotinny Arsenal Apparatus, in. 1	5 to 22	Refrective Index, no	
· · · · · · · · · · · · · · · · · · ·	7 to 20	n <mark>2</mark>	
		n <sup>2</sup>	
Fristion Pundulum Test:		Vocuum Stability Test:	(c)
	naffected	cc/40 Hrs, at	
Fiber Shoe U	naffected	90°C 0.20	
Rifle Sullet Impact Test: Trials			•••
96		*Average value of 5 gm sample lized from isoamyl alcohol.	. CALCE LECLARCET
Explosions			
Partials	`	`	
Burned		200 Grem Bemb Send Test:	
Unoffected		Sand, gm	59.2 54.1
Explosion Temperature: *C		Sensitivity to Initiation:	
Seconds, 0.1 (no cop used)		Minimum Detonating Charge, gm	)
1		Mercury Fulminate	0.200**
<b>5</b> 220		Leod Azide	0.100**
10 15		**Alternative initiating char	rges.
20		Bellistic Morter, % TNT:	130
75 'C International Host Test: % Loss in 48 Hrs		Plate Deat Test:	
		Method	
100 °C Heat Test:		Condition	
95 Loss, 1st 48 Hrs 8.	•79	Confined	
% Loss, 2nd 48 Hrs 2.	.98	Density, gm/cc	
Explosion in 100 Hrs No	one	Brisance, % TNT	
		- Detenation Rate:	(b)
Floramebility Index:		Confinement	None
		Condition	Cast
Muumeenielus & 30° a and pu	02		
Hygrescepicity: % 30°C, 90% RH 0.	.02	Charge Diameter, in.	1.2
Hygrescepicity: % 30°C, 90% RH 0.	.02	Density, gm/cc	1.2 1.42 7000 to 7300

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nin Verse

#### AMCP 706-177 Cyclotrimethylene Trinitrosamine 8ntation Test: Shoped Charge Effectiveness, TNT = 100: 90 mm HE, M71 Projectile, Lot WC-91: Glass Cones Steel Cones Density, gm/cc Hole Volume Charge Wt, ib Hole Depth Total No. of Fragments: Color: Yellow For TNT For Subject HE Principal Uses: Ingredient of projectile filler 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib Total No. of Fragm Mothed of Loading: Pressed or cast with added molting point depresents For TNT For Subject HE Loading Density: gm/cc See below int Velocity: ft/sec Frees At 9 ft At 25½ ft Storage: Density, gm/cc Method Dry Host (Relative to TNT): Hazard Class (Quantity-Distance) Class 9 **Compatibility Group** Group M Aim Peak Pressure Exudation None Impulse Energy Density at Various Pressures: (1) Air, Confi 4. 1b/inch<sup>2</sup> Impulse <u>ga/cc</u> 2,420 4,830 9,650 14,500 24,200 1.10 ler Weter: 1.23 Prok Pressure 1.37 1.44 1.53 1.57 1.59 Impulse Energy 33,800 42,500 reret d: Peak Pressure Heat of: Impulsa 3158 876 -914 Combustion, cal/gm Explosion, cal/gm Formation, cal/gm Emergy

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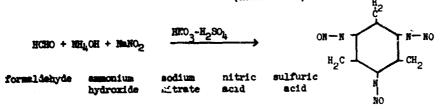
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#### Cyclotrimethylene Trinitrosanine

Preparation of Hexahydro-1, 3, 5-Trinitroso-s-triszine Cyclotrimethylene Trinitrossaine: (Reference a)



An aumoniacel solution of an amine is prepared by adding aqueous formaldehyde to ammonium hydroxids. The rate of addition of formaldehyde is regulated to maintain a solution temperature of  $30^{\circ}$  to  $35^{\circ}$ C.

Sodium nitrite is dissolved in water and the solution or slurry is then poured into the previously prepared amine-ammonia solution and totally dissolved by stirring. This solution is chilled to below 0°C.

Into a mixed acid solution, previously prepared by discolving concentrated mitric acid in water and adding concentrated sulfuric acid, all chilled to  $-9^{\circ}C$ , there is added the cold emins-mitrite solution below the surface of the acid mixture. The addition is regulated to take 0 to 20 minutes take 20 to 30 minutes.

The resulting foamy head of cyclotrimethylene trinitroramine is allowed to sit over the icy spent liquor for 1/2 hour and is then collected on a sintered glass funnel and veshed to neutrality. The moist cyclotrimethylene trinitrosamine is removed from the funnel and air-dried on filter paper. The dry grude product melts at  $105^{\circ}$  to  $107^{\circ}$ C. Recrystallization from isoamy alcohol gives a pure compound melting at  $105^{\circ}$  to  $107^{\circ}$ C.

#### Origin:

Cyclotrimethylene trinitrosamine was discovered in 1888 simultaneously by Griess and Harrow (Ber 21 (1888), p. 2737) and by Mayer (Ber 21 (1888), p. 2883) when sodium nitrite was allowed to react with hexamethylene tetramine in acid solution. This compound was later studied by Duten and Scherff (Ann 288 (1895), p. 218) and by Delepine who determined its heat of formation, which was negative (Bull Soc chim (3) 15 (1856), p. 1199). Because cyclotri-methylene trinitrosamine could be made at first in very poor yield only, it was a long time before it received consideration for practical application as an explosive. However, the study of cyclotrimethylene trinitrosamine was continued and investigations were made as to its behavior in mixtures with other substances (Prof. D. G. Römer "Report on Explosives," BIOSGP 2-HBC 5742).

#### Destruction by Chemical Decomposition:

Cyclotrimethylene trinitrosamine is easily decomposed by soid or alkali and even by boiling in water.

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#### Cyclotrimethylene Trinitrosamine

(b)

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High Temperature Decomposition, 0.02 gm in 10 ml Test Tube:

		Temp. CC
1)	Nelting begins	105
	Decomposition begins	150
	Mitrous gas	160
	Entire decomposition	170
2)	Some bubbles	110
•	Very slow decomposition	150
	Decomposes in 2 minutes	200
	Decomposes in 40 seconds	250
	Immediate decomposition	300

#### Lorg Term Stability: (b)

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Cyclotrimethylene irinitrosamine loosely packed in covered wooden boxes for six years at ambient temperature and protected from the sun:

- 1. Explosi a showed no color change.
- 2. Melting point decreased from  $104.5^{\circ}$  to  $104^{\circ}C$ .
- 3. Coefficient of "Utilisation Practique" decreased from 125.5 to 123.5.
- 4. An "bel Test at 110°C gave no color to iodine starch paper in 15 minutes.

Fusion Tests, Mixtures of Cyclotrimethylene Trinitromanine and TNT: (b)

Cyclotrimethylene Trinitzomanine, \$	·	Melting Point, C
10	;	74 68 62
20	1	68
30		62
<b>4</b> 0	:	55
42	:	55 (Eutectic)
50		55 (Eutectic) 61
50 60	÷	69
70		π
95		95

Eutectic Composition With TNT: (b)

Rate of Detonation, meters/second

7,000

42% Cyclotrimethylene Trinitrosamine 58% TNT

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#### Cyclotrimethylen \_\_\_\_\_initrossmine

Reaction of Cyclotrimethylene Trinitrosamine With Other Materials: (b)

1.	Iron powier	Slight reaction
2.	Copper powder	Slight reaction
3.	Aluminum powder	Slight reaction
4.	2 parts picric acid + 1 part R-Salt	<ul> <li>a. Violent decomposition after 2 hours at 10°C</li> <li>b. Violent decomposition after 10 to 15 minutes at 100°C</li> </ul>
5.	2 parts nitroglycerin + 1 part R-Smlt	No evidence of decomposition after 5 days at 90°C

Detonation Pr.te: (b)

Conf nement	Paper cartridge
C.dition	ressed
Charge Diameter, in.	1.18
Rate, meters/second	Density, gm/cc
5180	0.85
5760	1.00
6600	1.20
7330	1.40
7600	1.50
7800	1.57

### References:16

(a) Arthur D. Little, Inc. Progress Report No. 106, Fundamental Development of High Explosives, April 1955, Contract No. DAI-19-020-501-ORD(P)-33.

(b) Louis Médard and Maurice Dutour, "Étude Des Proprietés De La Cjelotriméthyléne Trinitrosamine," Mém poudr, <u>37</u>, 1924 (1954).

(c) H. A. Bronner and J. V. R. Kaufman, "Synthesis and Properties of R-Salt," PATR in preparation 1959.

(d) Also see the following Picatinny Arsenal Technical Reports on Cyclotri, thylene Trinitrosamine: 1174, 2179.

16See footnote 1, puge 10.

S. Brand

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DBX (Depth Bomb Explosive)

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Composition: %		Molecular Weight:	83		
Annonium Nitrate	21	Oxygen Belence:			
RIX	21	CO <sub>2</sub> %	-46 -26 -		
INT	40	Density: gm/cc Cast	1.68		
Aluminum	18	Melting Point: "C			
C/H Ratio	10	Freezing Point: "C			
impact Sanshtivity, 2 Kg Wt:		Boiling Puint: *C			
Bureau of Mines Apparotus, cm	35				
Sample Wt 20 mg Picatinny Arsenal Apporatus, in.	13	Refrective Index, No			
Somple Wt, mg	îĭ	n <sub>as</sub>			
		n <mark>a</mark> ,			
Friction Pondulum Test:		Vocuum Stability Test:			
Steel Shoe		cc/40 Hrs, at			
Fiber Shoe		90°C			
Life Bullet Impact Test: Trials		100°C			
%		120°C	6.15		
70 Explosions		135°C			
Portials		150°C			
Burned		200 Grem Bemb Sand Test:			
Unoffected		Sand, gm	58.5		
Explosion Temperature: •C		Suncitivity to Initiation:	· · · · ·		
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, gr			
		Mercury Fulminate			
5 Ignites 400		Lead Azide	0.20		
10		Tetryl	0.10		
15 20		Ballistic Mortor, % TNT: (a)	146		
		Troust Test, % TNT:			
5°C International Heat Test: % Loss in 48 Hrs		Plate Dant Test: (b)			
		Method	В		
00°C Heat Text:		Condition	Cast		
% Loss, 1st 48 Hrs		Confined	No		
% Loss, 2nd 48 Hrs		Density, gm/cc	1.76		
Explosion in 100 Hrs		Brisance, % TNT	102		
ionnebility Index:		Detenction Rote: (c)			
returned the state of the state		Confinement	None		
lygroscopicity: %		Condition	Cast		
• <b>;;;</b> •••• <b>•</b> •••; 70		Charge Diameter, in.	1.6		
eistility:		Density, gm/cc	1.65		
		Rate, meters/second	6600		

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### DBX (Depth Bomb Explosive)

	وموجود المائل ومعصور		
Beester Sensitivity Test:	(•)	Decempention Equation:	
Condition	Cast	Oxygen, atoms/sec	
Tetryl, gm	100	(Z/sec) Heat, kilocalorie/mole	
Wax, In. for 50% Detonation	1.35	(AH, kcal/mol)	}
Wax, gm		Temperature Range, °C	
Density, gm/cc	1.76	Phase	
Heat of: Combustion, col/gm	(d)	Armer Plote Impoct Test:	1
Explasion, cal/gm	1700	60 mm Morter Projectile:	
Gas Volume, cc/am		50% Inert, Velocity, ft/sec	
Formation, cal/gm		Aluminum Fineness	
Fusion, cal/gm			
		500-16 General Purpose Bembe:	1
Specific Heat: col/gm/*C	(d)		
-5°C, density 1.75 gm/cc	0.25	Plate Thickness, inches	
		1%	
		11/2	1
		172	Į.
Burning Rate:		• 74	
cm/sec			4
		Bound Drop Test:	
Thermal Conductivity: col/sec/cm/°C Density 1.75 gm/cc	13.2 x 10 <sup>-4</sup>	T7, 2000-16 Sami-Armon-Piercing Bomb vs Concrete:	0
Coefficient of Expansion:		Max Safe Drop, ft	
Linear, %/*C -73°-75°C	4.5 x 10 <sup>-5</sup>	500-16 General Purpose Bomb vs Concrete:	
Volume, %/*C		Height, ft	
		— Triols	
Hardness, Mohe' Scale:		Unaffected	1
	(á)	Law Order	
Young's Modulus:	$10.4 \times 10^{10}$	High Order	1
E', dynes/cm²	$10.4 \times 10^{-5}$ 1.51 × 10 <sup>6</sup>		1
E, Ib/inch <sup>2</sup>	•	1000-ib General Purpese Bomb vs Concrete:	
Density, gm/cc	1.72		
		Height, ft	l
Compressive Strongth: Ib/inch <sup>2</sup> (d)	3210-3380	Triais	
Density 1.78 gm/cc		Unaffected	1
Vapor Pressure:		Low Order	1
*C mm Mercury		High Order	
			-
			_

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### DBX (Depth Bomb Explosive)

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Fregmentation Test: 90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib Total No. of Fregments: For TNT		Shaped Charge Effectiveness, TNT = 100: Glass Cones Steel Cones Hale Vatume Hole Depth		
		For Subject HE		Principal Uses:
3 inch HE, M42A1 Projectile, Dansiny, gm/cc Chorge Wt, Ib	Let KC-3:			
Totol No. of Fregments: For TNT		Method of Looding:	Cast	
For Subject HE		Leading Density: gm/cc	1.61-1.69	
Frequent Velocity: ft/sec At 9 ft At 25½ ft	······································	Storege:		
Density, gm/cc		Method	Dry	
Blast (Relative to TNT):	(d)	Hazard Class (Quantity-Distance)	Class 9	
Air: Peak Pressure Impulse	118 127	Compatibility Group Exudation	Group I	
Ener.iy	138		•	
Air, Ceafined: Impulse		Preparation: DBX can be manufactured by		
Under Weter: Peak Pressure Impulse		water-wet RDX to molten TNT melted in a steam- jacketed kettle equipped with a stirrer. When all the water has evaporated, ammonium nitrate is added and with heating and stirring con- tinued, grained aluminum is added. The mix-		
Energy	136	ture is cooled with stirring maintain uniformity and when	continued to	
Underground: Peak Pressure		ing the mixture is cast. DBX by adding 21% ammonium nitrat	can also be made e and 18% alumi-	
Impulse Energy		num to 42% cyclotol or Compos PDN/TNT content plug 19% of T melted at about 100°C.	ition B of 50/50 NT previously	

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#### DBX (Depth Bomb Explosive)

#### Origin:

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DBX was developed and used by the United States and Great Britain during World War II. References: 17

(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives, Part III - Miscellaneous</u> <u>Sensitivity Tests; Performance Tests</u>, OSRD Report No. 5746, 27 December 1945.

(b) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(c) G. H. Messerly, The Rate of Detonation of Various Explosive Compounds, OSRD Report No. 1219, 22 February 1943.

M. D. Hurwitz, The Fate of Detonation of Various Compounds and Mixtures, OSRD Report No. 5611, 15 January 1945.

(d) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Second Revision, MAVORD Report No. 87-46, 26 July 1946.

(e) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for Tetryl in Boosters</u>, NOL Memo 10,303, 15 June 1949.

(f) Also see the following Picatinny Arsenal Technical Reports on DEX: 1585 and 1635.

17See footnote 1, page 10.

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Composition:		Molecular Weight: (C6H5N506	;)	243
%- с 29.6 н 2.1 <sup>о</sup> ₂ <sup>№</sup> Т		Oxygon Balance: CO <sub>2</sub> % CO %		
N 26.8	NH <sub>2</sub>	Density: gm/cc	Crystel	1.83
0 39.5	NO2	Molting Point: "C	(=)	290
C/H Ratio 0.380		Freezing Point: *C		
Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 18 Sample Wt, mg 9		Boiling Paint: "C		
		Refrective Index, nº nº nº		
Friction Pondulum Test: Steel Shoe Fiber Shoe		Vecuum Stubility Test: cc/40 Hrs, at 90°C		
	iols .	100°C 120°C		
Explosions	*	135°C 150°C		
Portials Burned		200 Grem Bomb Send Test:		
Unaffected		Sand, gm		46.6
Explosion Temperature: Seconds, C.1 (no cap used)	۰c	Sensitivity to Initiation: Minimum Detonating Charge,	, gm	
1		Mercury Fulminate		
5		Lead Azide		0.20
10		Tetryi		0.10
15 20		Bellistic Morter, % TNT:		100
		Treuzi Test, % TNT:		
75°C International Heat Test: % Loss in 48 Hrs		Plate Dent Test: Method		
100°C Heat Test:		Condition		
% Loss, 1st 48 Hrs	0.00	Confined		
% Loss, 2nd 48 Hrs	0.4	Density, gm/cc		
Explosion in 100 Hrs	None	Brisance, % TNT		
Flammability Indox:		Detenation Rate: Confinement		None
		Condition		Presse
Hygroscopicity: %		Charge Diameter, in.		0,5
		Density, gm/cc		1.55
Velatility:		Rate, meters/second		7500

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### AMCP 706-177

### 1. 3-Diamino-2,4,6-Trinttrobenzene (DATNB)

Fregmentation Test:	jhoped Charge Effectiveness, TNT = 100:	
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones St Hole Volume Hole Depth	eel Cones
Tetal No. of Fragments: For TNT	Color:	Yellow
For Subject HE	Principal Uses:	
<b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib		
Tetel Ne. of Fregments: For TNT For Subject HE	Method of Looding:	Pressed
Fregment Velocity: ft/sec	Looding Density: gm/cc At 50,000 ps1	1.65
At 9 ft At 25½ ft Density, gm/cc	Storage:	
	Method	Dry
Blast (Relevive to THT):	Hazard Class (Quantity-Distance	)
Air: Peak Pressure	Compatibility Group	None
Impulse Energy	Exudation	
Air, Cenfined: Impulse	<u>Cook-Off Temperature:</u> <sup>O</sup> C Time, minutes	<b>320</b> 8
Under Weter: Peak Pressure	Heat of: Explosion, cal/gm	2876
impulse Energy		
Underground : Peak Pressure		
Energy		
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, 200 mm. (

#### 1,3-Diamino-2,4,6-Trinitrobenzene (DATNB)

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#### Preparation:

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Fifty grams (50 gm) of dry styphnic acid was added to 200 gm of anhydrous pyridine with stirring. The resulting slurry was stirred for an additional 30 minutes. The yellow product, dipyridinium styphnate, was collected by filtration and washed with approximately 100 milliliters of diethyl ether. The product was dried over phosphorus (V) oxide, at room temperature, for 5 hours. Yield of 77 gm (94%), melting point 168° to  $170^{\circ}$ C (literature melting point 173°C).

To 50 milliliters of phosphorus oxytrichloride, 29.8 gm of the dipyridinium styphnate were added in small portions, with stirring. The reaction mixture was then warmed on a steam bath for 15 minutes. This solution was quenched in 500 gm of ice water. The light yellow precipitate was separated by filtration and washed with water until the washing was neutral to litmus. Yield of 1,3-dichloro-2,4,6-trinitrobenzene 20.4 gm (98%), MP 130 to 131°C (literature MP 128°C).

A suspension of 3 gm of 1,3-dichloro-2,4,6-trinitrobenzene in 9 milliliters of absolute methanol was prepared. This slurry was cooled to 0°C, and dry ammonia was bubbled into the stirred suspension. After 20 minutes the reaction mixture was allowed to warm to room temperature, filtered by suction and washed with methanol and ether until a negative Beilstein test for chloride ion was obtained on the wushings. Yield of 1,3-diamino-2,4,6-trinitrobenzene 2.5 gm (77%), MP 288° to 290°C (literature MP 285°C).

#### Origin:

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DATAB, also called 2,4,6-trinitro-1,3-diamino-benzol or 2,4,6-trinitro-phenylenediamine-(1,3), was first obtained by Noelting and Collin in 1884 (Ber 17, 260) and also by Barr in 1888 (Ber 21, 1546) from 2,4,6-trinitroresorcin dimethylether in contact with ammoniacal alcohol for several days. J. J. Blanksma obtained the same product in 1902 by reacting either 2-chloro-2,4,6-trinitroanisole or 3-chloro-2,4,6-trinitrophenetol with ammoniacal alcohol (Rec trav chim 21, 324) and from 2,4,6-trinitroresorcin methylethyl ether with ammoniacal alcohol (Rec trav chim 27, 56 (1908)).

Meisenheimer and Patzig in 1906 prepared DATNB in the form of yellow needles, MP  $280^{\circ}$ C from 1,3,5-trinitrobenzene ydroxylamine and sodium methylate in methyl alcohol (Ber 39, 2540). The product was slightly soluble in glacial acetic acid but poorly soluble in other solvents. It decomposed into NH<sub>3</sub> and 2,4,6-trinitroresorcin when boiled with dilute NaOH or KOH (Beil 13, 60).

Körner and Contardi prepared DATMB by the reaction of either 2,4-dichloro-1,3,5-trinitrobenzene or 2,4-dibromo-1,3,5-trinitrobenzene with armoniacal alcohol at room temperature or better by heating to  $100^{\circ}C$  (Atti R. Accad Lincei (5), 171, 473 (1908)); (5) 18 I, 101 (1909)). A method of preparation by prolonged reaction of N-nitro-N-methyl-2,3,4,6-tetranitroaniline with a saturated ammonia solution was reported in 1913 by van Romburgh and Schepers (Akad Amsterdam Versl 22, 297).

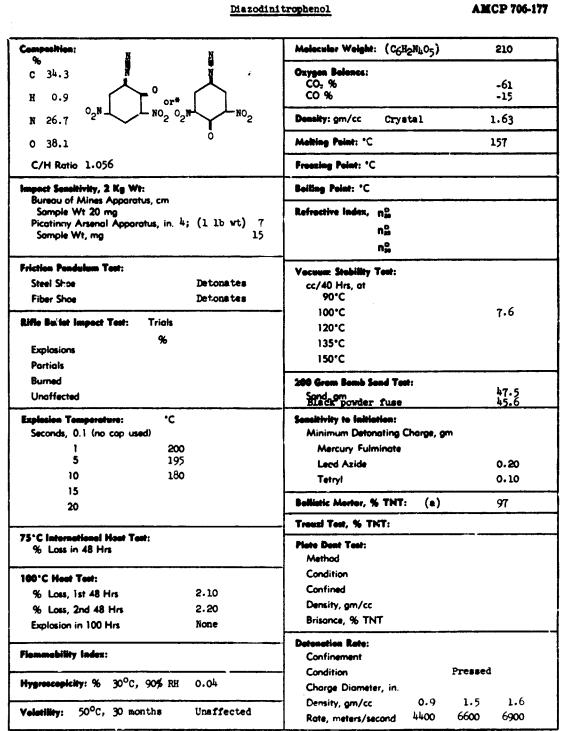
C. F. Van Duin obtained DATNB melting at 301°C by reacting a concentrated aqueous ammonia solution with N-nitro-N,N,N-trimethyl-2,4,6-trinitrophenylenediamine-(1,3) or with N-nitro-N-methyl-N-phenyl-2,4,6-trinitrophenylenediamine-(1,3) (Rec trav chim 38, 89-100 (1919)). Later Van Duin and Van Lennep reacted concentrated aqueous ammonia with 2,4,6-trinitro-3-aminophenetol to obtain DATNB melting at 237° to 288°C (Rec trav chim 39, 147-77 (1920)). In 1927 Lorang prepared the same compound by boiling 2,4,6-trinitro-1,3-bis ( -nitroethyl ureido) benzene with water or by heating it with summoniacal alcohol in a tube at 100°C (Rec trav chim 46, 649) (Beil E 17, Z II 33).

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### 1,3-Diamino-2,4,6-Trinitrobensene (DATMB)

A recent report describes the preparation of DAINE in two steps from commercially available starting materials. First m-mitroaniline was mitrated with HgSO<sub>4</sub>-ENO<sub>3</sub> acid mixture to tetramitroaniline. The crude tetramitroaniline was converted by methanolic ammonia to disminotrimitro-benzene in a high degree of purity. A conversion of 100 parts of m-mitroaniline into 110 parts of DAINE was obtained by this method, which can easily be carried out on a commercial scale.



\*Until it is established which picramic acid (melting point 169°C) isomer is involved (Ref: J Chem Soc, 2082, August 1949).

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### Diazodinitrophenol

Francisco and a state of the st	Shaped Charge Effectiveness, TNT = 100:	
Fregmentation Test:		
90 mm HE, M71 Projectile, Let WC-91:	Glass Cones Steel Cones	
Density, gm/cc	Hole Volume	
Charge Wt, Ib	Hole Depth	
Total No. of Fragments:	Color: Yellow needles	
For TNT		
For Subject HE	Principal Uses: Percussion caps	
3 inch HE, M42A1 Projectile, Lot KC-5:		
Density, gm/cc		
Charge Wt, Ib		
Totai No. of Fragments:	Method of Looding: Pressed	
For TNT		
For Subject HE	Looding Density: gm/cc Apparent 0.27	
Frequent Velocity: ft/sec	At 3000 psi 1.14	
At 9 ft		
At 251/2 ft	Storage:	
Density, gm/cc	Method Under water	
Siast (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9	
Air:	Compatibility Group	
Peak Pressure		
Impulse	Exudation None	
Energy	·	
Air, Confined:	Solubility:	
Impulse	Soluble in nitroglycerin, nitrobenzene,	
Under Weter: Peak Pressure	aniline, pyridine, concentrated hydrochloric acid, and in most common organic solvents.	
Impulse	Heav of:	
Energy		
Underground: Peak Pressure	Combustion, csl/gm 3243 Explosion, csl/gm 820 Gas Volume, cc/gm 865	
Impulse	Sensitivity to Electrostatic	
Energy	Discharge, Joules: (c) 0.012	

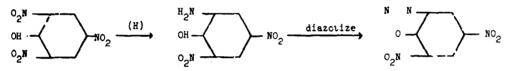
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Solubility: gm/100 and of the following substances: (c)

Solubility at 50	<u>°C</u>
Sclvent	ž
Etayl acetate	2.45
Methanol	1.25
Ethanol	2.43
Ethylenedichloride	0.79
Carbon tetrachloride	urace
Chloroform	0.11
Benzene	0.23
Toluene	0.15
Petrole un ether	Insoluble (at 20°C)
Ethyl ether	0.08 (30°C)
Carbon disulfily	trace (30°C)

Preparation: (Chemistry of Powder and Explosives, Davis)



Ten gm of picramic acid is suspended in 120 cc of 5% hydrochloric acid, and under efficient agitation at about 0°C. 3.6 gm sodi: n nitrite in 10 cc water is dumped into the suspension. Stirring is continued for 20 minutes, the product filtered off and washed thoroughly with ice water. The dark brown product, if (issolved in acctone and precipitated in water, turns brilliant yellow.

#### Origin:

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Discovered by Griess in 1858 (Annalen 106, 123; 113, 205 (1860) and studied extensively by L. V. Clark (Ind Eng them 25,  $6_3$  (1933). Developed for commercial use in 1928. This compound was patented in the United States by Professor William M. Dane.

### Destruction by Chemical Decomposition:

Diszodinitrophenol is decomposed ... adding the water-wet material to 100 times its weight of 10% sodi ... hydroxide. Nitrogen gas is evolved.

### References: 18

(a) Fullip C. Keenan and Dorothy Pines. Table of Military High Explosives, Second Revision, NAVORD Report No. 87-46, 26 July 1946.

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### Diazodinitrophenol

Electrostatic Discharges, U. S. Dept of Int, Bureau of Mines, RI 3852, 1946.

(c) L. V. Clark, "Diazodinit"ophenol, A Detonating Explosive," Ind Eng Chem 25, 663 (1933).

Seidell, <u>Solubilities of Inorganic and Organic Compounds</u>, Van Nostrand and Co., N. Y. (d) Also see the following Picatinny Arsenal Technical Reports on Diazodinitrophenol:

2	2	<u>4</u>	٤	1	<u>8</u>	2
150 610 2120	1352	34 214	355	827	318 1838	2179

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### Diethylene Glycol Dinitrate (DEGN) Liquid

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Composition: %	Melecular Weight: (C4H8N207)	196
$c 24.5 h_2 c 0 n_2$	Oxygen Belence:	
н 4.1 H <sub>2</sub> c	CO <sub>2</sub> % CO %	-41 - 8
$n 14.3 H_2^{c} > 0$	Density: gm/cc Liquid	1.38
	Melting Point: °C	2
0 57.1 $H_2 \dot{C} - 000_2$ C/H Ratio 0.143	Freezing Point: "C	
Impact Societivicy, 2 Kg Wt:	Soiling Point: 'C Decomposes	160
Bureau of Mines Apparatus, cm 100+ Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 9 Sample Wt, mg	Cefrective Index, n% n% n%	1.4498
Friction Pondulum Test:		
Steel Shoe Explodes Fiber Shoe	Vocuum Stability Test: cc/40 Hrs, at 90°C	0.0001001
Rifle Bullet Impact Test: Trials	100°C 120°C	0.3cc/20 hr/
% Explosions	135°C	
Portials	150°C	• • <u>· · · · · · · · · · · · · · · · · ·</u>
Burned Unaffected	200 Gram Bomb Sand Test: Sand, gm	42.2
Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 5 237 10 15	Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetry!	
20	Ballistic Mortur, % TNT:	90
	Treuzi Test, % TNT:	77
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Text: Method	
100°C Heat Test:	Condition	
% Loss, 1st 48 Hrs 4.0	Con Trined Denuity, am/cc	
% Loss, 2nd 48 Hrs 3.0 Explosion in 100 Hrs None	Brisance, % TNT	
	Detonation Rate:	
Flammability Index:	Confinement	
Mygroscopicity: %	Condition Charge Diameter, in.	
· · · · · · · · · · · · · · · · · · ·	Density, gm/cc	1.38
Voletility: $60^{\circ}C_{r}$ mg/cm <sup>2</sup> /hr 193		-

### AMCP 706-177

### Diethylene Glycol Dinitrate (DEGN) Liquid

Booster Sensitivity Test: Condition		Decomposition Equation: Oxygen, atoms/sec
Tetryl, gm	•	(Z/sec)
Wax, in. for 50% Detonation		Heat, kilocolorie/mole
Wax, gm		(ΔH, kcal/mol) Femperature Range, °C
Density, gm/cc		Phase
vensity, gm/cc		rna <b>se</b>
Meek of:	0700	Armor Plate Impact Test:
Combustion, col/gm	2792	
Explosion, cal/gm	841 704	60 mm Morter Projectile:
Gos Volume, cc/gm	796	50% Inert, Velocity, ft/sec
Formation, col/gm	2020	Aluminum Fineness
Fusion, cal/gm		500-ib General Purpose Bombs:
Specific Heet: cal/gr., 'C		
· · · ·		Plate Thickness, inches
		1
		14
		114
Burning Rate:		
cm/sec		Bomb Drop Test:
Thermal Conductivity:		
cal/sec/cm/°C		T7, 2000-lb Semi-Armor-Hiercing Bomb vs Concrete:
Coefficient of Expension:		Max Safe Drop, ft
Linear, %/*C		500-16 General Purpocs Bomb vs Cancrete:
Volume, %/°C		Height, ft
		Tris
tierdness, Mohs' Scale:		Unafre_red
Mar		Low Order
Young's Modules:		High Order
E', dynes/cm² 5. (b. (b. ch?)		
E, Ib/inch² Density, gm/cc		1000-th General Purpose Somb vs Concrete:
Cenariy, gri/cc		
Compressive Strength: Ib/inch <sup>2</sup>		Trials
-		Unoffected
Vapor Pressure:		Low Order
C mm Mercury		High Order
20 0.003		
0 0.130		
-		

### Diethylene Glycol Dinitrate (DEGN) Liquid

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Fregmentation Test:	Shaped Charge Effectiveness, TNT == 100:
90 mm HE, M71 Projectile, Let WC-91:	Glass Cones Steel Cones
Density, gm/cc	Hole Vc'ume
Charge Wt, Ib	Hole Depth
Victual No. of Fragments:	Colorless
For TNT	
For Subject HE	Principal Uses: Propellant compositions
3 inch ME, M42A1 Projectile, Lat KC-5:	
Density, gm/cc	
Charge Wt, Ib	
Total No. of Fragments:	Method of Loading:
For TNT	
For Subject HE	Looding Deusity: gm/cc
Fregment Velecity: ft/sec	
At 9 ft At 25½ ft	Storege:
Density, gm/cc	Method Liquid
Biest (Relative to TNT):	Hazard Class (Quentity-Distance) Class 9
Air:	Compatibility Group
Peak Pressure	
Impulse	Exudation
Energy	
Air, Confined:	Preparation: DECN can be prepared with approx mately 55% yield by adding diethyleneglyce
Impulse	to mixed acid (50% HNC3, 45% H <sub>2</sub> SO <sub>4</sub> , and 5
	H <sub>2</sub> O). The temperature is kept at 30°C or
Under Weter: Peak Pressure	lower. The separated DEEN is purified by washing with successive portions of water
Impulse	dilute sodium carbonate solution and water
Energy	until neutral.
	Hydrolysis % Acid:
Underground: Peak Pressure	10 days at 22°C         0.003           5 days at 00°C         0.003
Impulse	Solubility in Weter, gm/100 gm, st:
Energy	<u>25°C</u> 0.40 60°C 0.40
Viscosity, centipoises:	Colubility, gm/100 gm, at 25°C, in:
Тетр, 20 <sup>0</sup> С 8.1	Alcohol 00
10mp, 20 C 0.1	2:1 Ether:Alcohol 00
	Acetone 00

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### Diethylene Glycol Dinitrate (DEGN) Liquid

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#### Origin:

First prepared and studied by Wm. H. Rinkenbach in 1927 (Ind Eng Chem 12, 925 (1927) and later by Rinkenbach and H. A. Aaronson (Ind Eng Chem 23, 160 (1931)) both of Picatinny Arsenal. Used in propellant compositions by the Germans during World War II.

#### <u>Lestruction by Chemical Decomposition:</u>

DEGN is decomposed by adding it slowly to 10 times its weight of 18% sodium sulfide (Nw2S'9H2O). Heat is liberated by this reaction but this is not haza jous if stirring is maintained during the addition of DEGN and continued until solution is complete.

### Reierences: 19

See the following Picatinny Arsenel Technical Reports on DEGN:

<u>0</u>	1	2	3	<u>4</u>	<u>6</u>	I	2
50 180 620 1490 1990	231 551 1391 1421	72 602 1282 1392	673 1443	494 1624	346 1516 1616 1786	487 1427 1487 1817	<b>279</b> 579 1439

<sup>19</sup>See fooinote 1, page 10,

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### Bis(2,2-Dinitropropyl) Fumarate (DNPF)

AMCP 706-177

Composition:	Meleculer Weight: (C <sub>10</sub> H <sub>12</sub> N <sub>4</sub> O <sub>12</sub> )	380		
% с 31.6 сноо <sub>2</sub> сн <sub>2</sub> с(NO <sub>2</sub> ) <sub>2</sub> сн <sub>3</sub> н 3.2	Oxygen Belance: CO <sub>2</sub> % CO %	-59 -17		
N 14.7 CHC02CH2C(N02)2CH3	Density: gm/cc Crystal	1.60		
0 50.5	Metting Point: °C Form I Fort II	89 86		
C/H Ratio	Freezing Peint: "C			
Impact Sensitivity, 2 Kg Wt:	Beiling Point: *C			
Bureau of Mines Apparatus, cm 100+ Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 18 Sample Wt, mg 18	Refractive Index, nº nº nº			
Friction Pendulum Test:	Vecuum Stability Test:			
Steel Shoe Unaffected	cc/40 Hrs, at			
Fiber Shoe Unaffected	90°C	•		
Kifle Bullet Impact Test: Trials	'00.C	0.66		
•	120°C			
% Explosions	135°C	0.91		
Partials	150°C			
Burned	200 Grem Bomb Sand Test:			
Unaffected	Sand, gm			
Explosion Temperature: °C Seconds, 0.1 (no cap used)	Sensitivity to Initiation: Minimum Detonating Charge, gm			
1	Mercury Fulminete			
4 Smokes 250	Leod Azide			
10	Tetryl			
15 20	Ballistic Morter, % TNT:			
	Trouzi Test, % TNT:			
75°C International vloat Test: % Loss in 48 Hrs	Plate Dent Test: Method			
100°C Heet Test:	Condition			
% Loss, 1st 48 Hrs	Confined			
% Loss, 2nd 48 Hrs	Dansity, gm, cc			
Explosion in 100 Hrs	Brisance, % TNT			
Flammability Index:	Confinement			
Αθουρογιατικό το	- Condition			
Hygroscopicity: %	Charge Diameter, in.			
Velstility:	Density, gm/cc	1.49		
• ••••••••••••••••••••••••••••••••••••	ate, meters/second	F1050		

#### CP 706-177

### Bis(2,2-Dinitropropyl) Fumarate (DNPF)

Fregmentation Test;	Sheped Charge Effectiveness, Ti	NT = 100:
90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, ib	Glass Cones Hole Volume Hole Depth	Steel Cones
Total No. of Fragments: For TNT	Celer:	White
For Subject HE <b>3 inch HE, M42A1 Projectile, Lot KC-5:</b> Density, gm/cc Charge V/t, Ib	Principel Uses:	
Totel No. of Fregments: For TNT For Subject HE	Mathod of Looding:	Cast
Fregment Velocity: ft/sec	Looding Density: ym/cc	1.50
At 9 ft At 25½ ft Density, gm/cc	Storage:	
Blast (Relative to TNT):	Method Hozard Class (Quantity-Distar	Dry
Air: Peak Pressure	Compolibility Grc p	
Impulse Energy	Exudation	None
Air, Confined: Impulse	Heat of: Combustion, cal/gm	3070 (calculated)
Under Water: Peak Pressure Impulse	Detonation, cal/gm Viscosity, poises:	707 (calculated)
Energy	Cemp, 98.9°C 106.5°C	0.556 0.435
Underground: Peak Pressure Impulse Energy	Liquid Density, gm/cc: Temp, 96.9 <sup>9</sup> C 106.5 <sup>9</sup> C <u>Origin:</u> Synthesizea in 1952 by U.C. Navat Ordnance Labor Mar. Tand.	

#### Bis(2,2-Dinitropropyl) Fumarate (DNPF)

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#### Preparation:

### (**a**, b)

HC-COC1    + 2C1 HC-COC1	н <sup>3</sup> с(.10 <sup>5</sup> )5сн <sup>5</sup> он ——	Alcl <sub>3</sub> HC	-со <sub>2</sub> сн <sub>2</sub> с(No <sub>2</sub> ) <sub>2</sub> сн <sub>3</sub> -со <sub>2</sub> сн <sub>2</sub> с(No <sub>2</sub> ) <sub>2</sub> сн <sub>3</sub>	
3.3 mol fummaryl chloride	7.3 mol 2,2-dinitropropanol	1.6 mol aluminum chloride	∂3% yield bis(dinitropropyl)	fumarate

Dinitropropanol was mixed with chloroform (1320 milliliters) and the mixture heated to boiling. The distillate was collected in a water separator. At first the distillate was cloudy and this was dried with calcium chloride before being returned to the system. When no more water was collected in the water separator, the mixture was cooled to room temperature and the separator removed. Fumaryl chloride was introduced, followed by the aluminum chloride which was added in four equal portions. Air was blown into the flask for a minute to effect mixing, and the reaction sustained itself without the addition of heat for one hour. Steam was gradually introduced so that the reflux temperature was reached 2-1/2 hours after the beginning of the reaction. After 3 hours of reflux, the hot liquid was poured into a bucket. As cooling took place the slurry was vigo isly agitated until it finally set up at room temperature. This material was boken up and mixed with dilute ice cold NCL. The solid product was collected on a sintered funnel, washed with water and with heare. The crude material was recrystallized from methanol to give a product melting at  $36^{\circ}C$  (uncorrected), but after storage for several days the melting point was  $89^{\circ}C$ .

### References: 20

(a) M. E. Hill, Preparation and Properties of 2,2-Dinitropropanel Esters, NAVORD Report No. 2497, 3 July 1952.

(b) D. L. Koubs and H. D. McNeil, Jr., Hercules Report on High Explosives. Lavy Contract Nord-11280, Task A, 26 May 1954.

20 See footnote 1, page 10.

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### Bis(2,2-Dinitropropyl) Succinate (DNPS)

Composition: %	Molecular Weight: $(C_{10}^{i_1} N_4 O_{12})$	382		
c 31.L	Oxygen Balance:			
H 3.7	CO: % CO %	-63 -21		
CH2CO2CH2C(NO2)2CH2		-61		
N 14.7	Density: gm/cc Crystal	1.51		
$\begin{array}{c} & & & \\ & & & & \\ & & & \\ & & & \\ & & & \\ & & & \\ & & & & \\ & & & \\ & & & & \\ &$	Mailting Point: "C	86		
C/H Ratio 0.250	Frenzing Point: "C			
Impact Sanshivity, 2 Kg Wt:	Boiling Point: *C			
Bureau of Mines Apparatue, cm Sample Wt 20 mg	Refrective Index, ng			
Picatinny Arsenal Apparatus, in.	n			
Sample Wt, mg				
	n <sup>o</sup>			
Fristiun Pendulura Test:	Vecuus. Stability Test:			
Steel Shoe	cc/40 Hrs, ot			
Fiber Shoe	90°C			
Rifle Bullet fixpect Test: Trials	;00°C	0.10		
%	120°C			
Explosions	135°C			
Partials	150°C			
Burned	200 Grem Bomb Send Test:			
Unoffected	Sond, gm			
Explusion Temperature: 'C	Sensitivity to Initiation:			
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gm			
1	Mercury Fulminate			
5 >400	Leod Azide			
10	Tetryl			
15 20	Ballistic Mortor, % TNT:			
20	Trauzi Test, % TNT:			
75°C International Host Test: % Loss in 48 Hrs	Plate Dent Test:	······		
	Method			
100°C Heat Test:	Condition			
% Loss, 1st 48 tirs	Confined			
% Loss, 2nd 48 Hirs	Censity, gm/cc			
Explosion in 100 Hrs	Brisance, % TNT			
	Detenstion Rate:	······································		
Flammability Index:	Confinement			
	Condition			
Hygroscopicity: %	Charge Diameter, in.			
No. Latitu	Density, gm/cc			
Veletility:	Rate, meters/second			

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#### AMCP 706-177 Bis(2,2-Dinitropropyl) Succinate (DNPS) Frugmentation Test: Sheped Charge Effectiveness, TNT = 190: 90 mm EE, M71 Projectile, Lot WC-91: Glass Cones Steel Cones Density, gm/cc Hole Volume Hole Depth Chorge Wt, Ib Total No. of Progmants: Celer: White For TNT For Subject HE Principal Uses: 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, ib **Total No. of Fragments:** Mothed of Loading: Cast For TNT For Subject HE Loading Density: gm/cc Fregment Velocity: ft/sec At 9 ft At 251/2 ft Storage: Density, gm/cc Method Dry Bleet (Relative to TNT): Hazard Class (Quantity-Distance) 1000 Compatibility Group Air: -Peak Pressure Exudotion Impulse None Energy Origin: Air, Confined: Impulse Synthesized in 1953 by M. E. Hill of the U.S. Naval Ordnance Laboratory, White Oak, Under Weter: Peok Pressure Maryland. impulse Energy Underground: Peak Pressure Impulse Energy

#### AMCP 706-177

### Bis(2,2-Dinitropropyl) Succinate (DNPS)

### Preparation:

5сн <sup>3</sup> с(и⊃ <sup>5</sup> )5сн <sup>5</sup> он	+	СН20001 СН20001	AlCl <sub>3</sub>	сн <sub>2</sub> слосн <sub>5</sub> с(ио <sup>5</sup> ) <sup>5</sup> сн <sup>3</sup> + снсг сн <sup>5</sup> соосн <sup>5</sup> с(ио <sup>5</sup> ) <sup>5</sup> сн <sup>3</sup>
dinitropropanol		succinyl chloride	aluminum chloride	bis(2,2-dinitropropyl) succinate

(a)

A methylene chloride solution of dinitropropanol (0.02 mol 'n 15 milliliters) was mixed with 0.01 mol of succinyl chloride. To this solution 0.003 mol of crushed anhydrous aluminum chloride was added. It was necessary to cool the reaction vessel due to the vigorousness of the reaction. After 25 minutes at room temperature the reaction, solution was refluxed 1-1/2 hours. Fine needle-like crystals formed upon cooling and adding hexane. The crystals were slurried in dilute hydrochloric acid and on recrystallization from methanol gave a 93% yield of INPS (melting point  $85^{\circ}$  to  $85.6^{\circ}$ C).

### References: 21

(a) M. E. Hill, Synthesis of New High Explosives, NAVORD keport No. 2965, 1 April 1953.

1

21Seg footnote 1, page 10.

Constant of

#### 2,2-Dinitropropy1-4,4,4-Trinitroputyrate (DNPTB)

AMCP 706-177

Composition: %	Melecular Weight: (C7H9N5012)	355
~~ C 23.6	Oxygen Belence;	
	CO <sub>2</sub> %	-29
H 2.5 0CH2C(NO2)2CH3	<u> </u>	+2.3
N 19.7 C-0	Density: gm/cc Crystal	1.68
0 54.2 CH2CH2C(NO3)	Maining Point: *C Form I 11 For Form III 59	na II 95
C/H Rotio	Fruezing Point: *C	
agent Sensibility, 2 Kg Wt:	Bolling Point: *C	
Bureau of Mines Apparatus, cm Sample Wit 20 mg	Refective Index, no	
Picotinny Arsenal Apparatus, in	ng	
Sample Wt, mg		
Polsten Peúdulum Test:	Vacuum Stability Test:	
Stuel Shoe	cc/40 Hrs, at 90°C	_
Fiber Shae		0.5
Rite Build Import Test: Trists	120°C	0.5
<b>%</b>	135°C	-
Explosions	150°C	
Particle		
Burnud	200 Gram Bamb Sand Test:	
Unoffected	Sand, gm	
Replation Temperature: *C	Southinity to Initiation:	
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gm	
) F	Mercury Fulminate	
5 300	Lead Azide	
10	Tetryl	
20	Bellistic Mortur, % TNT:	
· · · · · · · · · · · · · · · · · · ·	Truest Teet, % TRT:	
75°C International Next Text: % Lass in 43 Hrs	Plate Dent Test:	·····
	Method	
100°C Heat Text:	Condition	
% Loss, 1st 48 Hrs	Confined	
% Loss; 2nd 48 Hrs	Density, gm/cc	
Explosion in 100 Hrs	Brisance, % TNT	
	Detenstion Rate:	
flammability Index:	Confinement	
	Condition	
Hygroscopicity: %	Charge Diometer, in.	
Vejetility:	Density, gm/cc	1.67
( contract y :	Rote, meters/second	7600

#### AMCP 706-177

### 2,2-Dinitropropyl-4,4,4-Trinitrobutyrate (DNPTB)

Fregmentali en Tent:	Shaped Charge Effectiveness, TNT = 100:		
96 sun HR, M71 Projectin, Let WC-91: Denaity, gm/cc Chorge Wt, ib	Glass Cones Steel Cones Hole Volume Hole Depth		
Total No. of Progmants: For TNT	Color: White		
For Subject HE	Principal Uses:		
3 Inch MI, MAZA1 Projectile, Let KC-5: Dansity, gm/cc Charge Wt, Ib			
Tatal Ha. of Progmants: For TNT For Subject HE	Method of Looding: Cast		
	Loading Density: gm/cc 1.67		
Program Valuelty: ft/sec At 9 R At 25% ft	Storego:		
Density, gm/ct	Method Dry		
Diast (Relative to THT):	Hazard Class (Quantity-Distance)		
Alr: Poak Pressure https://se	Compatibility Group Exudation None		
Enorg,	Heat of: (c) Solute	<u> </u>	
Air, Confined: Impulse	$\begin{array}{c c} \hline \textbf{Solvent} \\ \hline \textbf{Transition, cal/gm} & \underline{\text{CCl}_1} & \underline{\textbf{IMF}} \\ \hline \textbf{I} & \hline \textbf{III} & 6.2 & 4.8 \end{array}$		
Under Weter: Peak Pressure	II -16.6 -22.0		
Impulse Energy	Heat of Solution, 30°C: <u>AH</u> Solution, cal/gm		
Underground:	Material CCL, DMP		
Peak Pressure	Form III 29.5 8.1 Form I 35.6 12.8		
impulse Energy	Form II 19.1 -9.1		
•	Origin. Synthesized in 1952 by M. E. Mill of t U.S. Naval Orgnance isboratory, White Osk Maryland.		

### 2,2-Dinitropropy1-4,4,4-T.initrobutyrate (INPTB)

AMCP 706-177

Preparation:	(a, b)	
CH3C(1702)20H +	<sup>/</sup> 110 <sup>2</sup> ) <sup>3</sup> cat <sup>5</sup> at <sup>5</sup> coa	AICI3
dinitropropenol	trinitrobutyryl chloride	eluminum chlorića
-	CH <sup>3</sup> C(20 <sup>5</sup> ) <sup>5</sup> CH <sup>5</sup> COCCH <sup>5</sup> C(2	0 <sub>2</sub> ) <sub>3</sub> + HCl <sup>↓</sup>
	dinitropropyl triaitrob	utyrate

(c)

Dinitropropenol, trinitrolutyryl chloride and eluminum chloride were slowly mixed in carbon tetrachloride at  $60^{\circ}$ C. This mixture was refluxed at  $75^{\circ}$ C for two hours. After the reaction was completed, the mixture was cooled and the crystalline product separated and purified. Water in the dinitropropenol was removed by assotropic distillation before the acid chloride was added. The purified product had a melting point of  $95^{\circ}$  to  $96^{\circ}$ C.

#### Crystallographic Data:

•

Three distinct crystallographic modifications of UMPTR have been observed. These polymorphs have been characterized by means of X-ray diffraction and microscopic observation. Form I crystallizes from solution in carbon tetrachloride, chloroform, acetone, chloroformbezame, soctone-water, or methanol-water at room temperature. Prolonged standing of Form I at room temperature under the mother liquid promotes a transition to Form II. Upon solidification of moltan DMPTB, Form II is always observed.

Linear Bate of Transformation of Form II to Form I (c)

Temperature,	Average Rate, sq inch/hour	Standard Deviation	Average Rate, mm/hcur
15	0.347	0.036	0.012
20	0.435	0.025	0.128
25	0.452	0.048	0.133
30	0.475	0.049	0.140
<b>3</b> 5	0 <b>.</b> 253	0.037	0.0,5

Both Forms I and III gave very erratic sensitivity values. The high temperature polymorph, Form II of DMPTB, gave consistent sensitivity values.

### References: 22

(a) W. E. Hill, <u>Preparation and Properties of 2,2-Dinitropropenol Esters</u>, MAVORD Report No. 2497, 3 July 1952.

(b) W. B. Hewson, Hercule: Report on High Explosives, Mavy Contract MOrd-11280, Task A, 18 October 1954.

(c) J. R. Holden and J. Wenograd, <u>Physical Properties of an Experimental Castable Explo-</u> sive 2,2-Dinitropropyl 2,4,4-Trinitrobutyrate DMPTB, MAVORD Report No. 4427, 11 December 1956.

<sup>22</sup>See foornote 1, page 10.

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### 2,4-Dinitrotoluene (DNT)

Compacition: % CH3	Melecular Weight: (C7H6N204)	1.82
	Oxygen Balance: CO <sub>2</sub> % CO %	-114 - 53
N 15.4	Density: gm/cc	1.521
Ý	Molting Point: "C	ก
0 35.0 No <sub>2</sub> C/H Ratio 0.579	Freezing Point: "C	
Import Sensitivity, 2 Kg Wt:	Beiling Point: "C Decomposes	300
Bureau f Mines Apparatus, cm Samtle Wt 20 mg Picatinny Ansenal Apparatus, in. Sample Wt, mg	Refrective index, pro- train	N. N
Steel Shoe         Unaffected           Fiber Shoe         Unaffected	Vecuum Stobility Test cc/40 Hrs, at 90°C 100°C	
Rifle Builet Impact Test: Trials % Explosions 0 Pertials 0	120°C 135°C 150°C	0.04
Burned 0 Unoffected 100	200 Grem Bemb Send Terre Sand, gm	19.3
Explosion Temperature: °C Seconds, 0.1 (no cap used) 1 5 Decomposes 310 10	Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide	0.20 0.25
15		
20	Ballistic Mortor, % TNT: (a) Trouzi Tost, % TNT: (b)	71 64
75°C International Host Test: % Loss in 48 Hrs	Plete Dent Test: Method	<u></u>
100°C Heat Test: % Loss, 1st 48 Hrs	Condition Confined	
% Loss, 1st 40 mms % Loss, 2nd 48 Hrs	Density, gm/cc	
Explasion in 100 Hrs	Brisance, % TNT	
Fix wability ladex:	Detenation Rate:     Confinement	
Hygrescepicity: % 25°C, 100% RH 0.00	Condition     Chorge Diameter, in.	
Volotliity:	Density, gm/cc Rate, meters/second	

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### 2,4- initrotoluene (DNT)

AMCP 706-177

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fregmentation Test:	Shoped Charge Effectiveness, TNT	== <b>100</b> :
90 mm HE, M71 Projectile, Let WC-91:	Glass Cones Str	el Cones
Density, gm/cc	Hole Volume	
Cinorge Wt, ib	Hole Depth	
Total No. of Fragments:	Geler:	¥233.000
For TNT		Yellow
For Subject HE		
	Principal Uses: Ingredient of powder, dynam	
3 Inch HE, M42A1 Projectile, Let KC-S:	plastic explo	
Densky, gm/cc Charge Wt, ib		
Charge Wit, io		
Total No. of Fragments:	Method of Loading: Pressed, e	traded on en
For TNT	compositio	
For Subject HE		
	Loading Dunsity: gm/cc	Verieble
vegment Velocity: ft/sec		
At 9 ft At 25½ ft	Storege:	
Density, gm/cc		
	Method	Dry
last (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 12
Ain	Compatibility Group	Group D
Pack Pressure		
Impulse	Exudotion	
Energy		
Air. Canfinad:	65.5°C KI Test:	
impulse		60+
	Minutes	
Under Weter: Pack Pressure	Heat of:	
Impulse	Combustice, cal/gm (b)	) 1545
Energy		
	Thermal C ductivity:	
Underground: Per' Pressure	cal, sec/cm/°C	<b>ب</b>
Im, de	Density 1.322 gm/cc	6.28 x 10 <sup>-1</sup>
Energy	ł	
<b>v</b> 7		

See United Section 200

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2,4-Dinitrotoluene (DNT)

### Preparation:

See THT.

Solubility: gm/100 gm of the following substances:

Rthyl	305 Alcohol	Mitro	lycerin		Water
° <u>c</u>	ź	<u>ې</u>	2	°C	ž
25 33 5 56	0.16 0.29 0.49 0.77 1.03	20	30	22 50 100	0.027 0.037 0.254

### Solubility at 15°C, in:

Solvent	٤	Solvent	٤
CHCL3 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.15 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.14 Cr.15 Cr.14 Cr.15	65.076 2.4 <u>31</u> 60.644 45.470 5.014 1.916	C.H.CH (absolute) Ether (absolute) Acstone Ethyl acetate CS2 Pyridine	3.039 7.422 82.931 57.929 2.306 76.810

Origin:

Occurs as 75% of the products obtained on the nitration of toluene, the remaining 25% being mainly 2,6-INT and other isomers of DNT. Also occurs as an impurity in crude TNT obtained by standard manufacturing process. .sed in explosive mixtures at least since 1931.

### References: 23

(a) L. C. Smith and E. G. Ryster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OCRD Report No. 5746, 27 December 1945.

(b) A. H. Elatt, <u>Compilation of Data on Organic Explosives</u>, OSRD Report No. 2014, 29 February 1944.

(c) Report AC-2861.

(d) Also see the following Picatinny Arsenal Technical Reports on DKT:

810 13	51 72 01 77	43	304	2625	- 04			
1830 154 16 17 18 20 22	21 1672 31 1692	1023	394 804 1044 1094 1094 1284 1464 1524 1674 1754 2094	1615 2125	186 1556 1816 1896	97 817 837	768 938 1538	69 149 249 279 779 1749

23See footnote 1, page 10.

Compatition: %	Moleculer Weight: (C10H16N6019)	554		
C 21.7 H 2.9 N 15.2 ONO,	Co %	-26 ⇒ 3		
0 00.2 CH	CH2 Density: gm/cc Crystal	1.63		
ом <sub>2</sub> эсн <sub>2</sub> с́−сн <sub>2</sub> −с−сн <sub>2</sub> Сн	- CCH20N02 Melting Point: 'C	73.7		
C/H Rotio 0.154 002	CH Brossing Point: "C			
Report Sonshirity, 2 Kg Wt: Bureau of Mines Apparatus, cm 14	Builing Point: *C			
Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 4 Sample Wt, mg 10	Refructive Index, no no no no	n <sub>ao</sub>		
Filetion Fundatum Yest: Steel Shoe Explo Fiber Shoe Unafi	erted 90°C			
Ritto Buillot Impoct Test: Trials	100°C 120°C	3.7 11+		
%	135°C			
Explosions	150°C			
Portiols				
Burned Unaffected	200 Grem Bemb Sand Test: Sand, gm	57.4		
Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 300 5 Explodes 255 10	Sensitivity to Initiation: Minimum Dotonating Charge, gm Mercury Fulminate Lead Azide Tetryl			
15 26	Ballistic Monter, % TNT: (a)	142		
	Trussi Test, % TNT: (b)	128		
75°C Inturactional Host Test: % Loss in 48 Hin	Plate Deat Test: Method			
100°C Hoat Test:	Condition			
% Loss, 1st 48 Hrs 0.11	Confined			
% Loss, 2nd 48 Hrs 0.10	Density, gm/cc			
Explasion in 100 Hrs None	Brisonce, % TivT			
Flammebility Index:		Copper tube		
Hygrescepicity: % 0.03	Condition Chorge Diameter, in.	P <b>ressed</b> 0.39		
	Density, gm/cc	1.59		

#### Dipentaerythritol Hexanitrate (DPENN)

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#### AMCP 706-177

### Migentaerythritol Hexanitrate (DPENN)

Fregmentation Test:	Sheped Charge Effectiveness, TNT = 10	N\$:
90 min HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, ib	Glass Cones Steel C Hole Volume Hole Depth	ones
Total No. of Fregments: For TNT	Color:	White
For Subject HE 3 i.uch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib	Principal Uses: Ingredient of pr compositions	iming
Total No. of Fragmants: For TNT	Mathod of Loading:	Pressed
For Subject HE	Leading Density: gm/cc	
Fregment Valocity: ft/sec	At 3000 to 4000 psi	1.59
At 9 ft At 25½ ft	Storege:	
Density, gm/cc	Method	Dry
Binst (Relative to TNT):	Hazard Class (Qunntity-Distance)	Class 9
Air: Peak Pressure Impulse Energy	Compotibility Group	
Air, Contined: impulse	Preparation: (Chemistry of Powd Explosives, Davis)	er and
Under Weter: Pook Pressure Impulse Energy	2(HO-CH <sub>2</sub> ) <sub>4</sub> C <u>Dehydration</u> (HO-CH <sub>2</sub> ) <sub>3</sub> C-O-C(CH <sub>2</sub> -OH) <sub>3</sub> (O <sub>2</sub> NO-CH <sub>2</sub> ) <sub>3</sub> C-O-C(CH <sub>2</sub> -OHO <sub>2</sub> ) <sub>3</sub> Dipentaerythritol Hexanitra	
Underground: Peak Pressure	in the pure stats (melting poi fractional crystillization of from moist acetone.	nt 72°C) by
Impulse Energy	Origin: Formed as an impurity ration of PETN. Properties by W. Frederick and W. Brün (Berichte 63, 2861 (1930); Z Sprengstoffw 27. 73-6, 125-7	first described in 1930 . ges Schiess-
	Heat of: Combustion, cal/gm	2260

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### Dipentacrythritol Hemanitrate (DPENN)

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### References: 24

<sup>24</sup>See footnote 1, page 10.

Carsen .

(a) L. C. Smith and E. G. Ryster, <u>Physical Testing of Explosives, Part III - Miscellaneous</u> <u>Sensitivity Tests; Performance Tests</u>, OCRD Report No. 5746, 27 December 1945.

(b) A. Stettbacher, <u>Die Schiess und Sprengstoffe</u>, Leipsis, p. 363.

(c) T. L. Bavis, <u>The Chomistry of Powder and Explosives</u>, John Wiley and Sons, Inc., New York (1943) pp. 218-283.

(d) 8. Livingston, <u>Characteristics of Explosives HAX and DPHEN</u>, PATR No. 1561, 6 September 1945.

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#### Dynamite, Low Velocity, Picatinny Arsenal (LVD)

Composition: 99.5/0.5 RDX/1-MA dye* 17.5	Molucular Weight:	
% INT 67.8	Oxygen Bolence:	
Tripentaerythrito! 8.6	CO <sub>2</sub> %	
68/32 Vistac No 1/DOS binders** 4.1	CO %	]
Cellulose acetate, LH-1 2.0		{
RDX, Class E; 1-MA is 96% pure 1-methylamino- anthraquinone.	Benefty: gm/cc Loading 0.9	
HWVistac No 1 is low MW polybutene; DOS is	Mailing Point: "C	1
lioctylsebacate. C/H Ratio	Pressing Point: "C	-1
Import Sensitivity, 2 Kg Wt:	Bolling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	Refroctive Indea, ng	
Picatinny Arsenol Apparatus, in. 22		
Sample Wt, mg 19	n <sup>D</sup> <sub>25</sub>	1
	n <mark>o</mark> n	
Friction Pondulum Test:	Vo.sum Stability Test:	
Steel Shoe Unaffected	cc/40 Hrs, at	
Fiber Shoe Unaffected	90°C	1
	- 100°C	
Rifle Sullet Impact Test: Trials	120°C 0.90	
<b>%</b>	135°C	1
Explosions	150°C	ł
Portiols		
Burned	208 Greate Bemb Send Test:	Ì
Unaffected	Sand, gm 40.5	Ι.
	-	(°
Explusion Temperature: °C	Sensitivity to Initiation:	N
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gm	
1	Mercury Fulminate	
5 Ignites 480	Lead Azide 0.20	[
10	Tetryl 0.15	1
15		
20	Buillatte Caster, % ATT: 92	
75°C International Heat Test:	Trend Test, W 7%T:	
% Loss in 48 Hrs	Plate Dant Test. Method	
	Condition	
100°C Heet Test:	Confined	
% Loss, 1st 48 Hrs		
% Loss, 2nd 48 Hrs	Density, gm/cc	
Explosion in 100 Hrs	Brisance, % TNT	
·		
Planmability Index:	Confinement None	
		ļ
Hygrescepicity: % 0.31	Condition Hand tamped	1
Mygrescepicity: % 0.31 71°C, 95% RH. 30 days Satisfactory	Charge Diameter, in. 1.25	
		1
Velstility:	Density, gm/cc 0.9 Rate, meters/second 4397; or 14400 ft/sec	1

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### Dynamite, Low Velocity, Picetinny Arsenal (LVD)

AMCP 706-177

Fregmentetion Test:	Shapad Charge Effectiveness, TNT = 100:
90 mm HE, M71 Projectile, Sat WC-91: Density, gm/cc Charge Wt, Ib Tatal No. of Fragments:	Glass Conus Steel Cones Hole Volume Hole Depth
For TNT	Color: Pink
For Subject HE 3 Insh ME, MARAT Projectile, Let KC-S: Dansity, gm/cc Charge Wt, Ib Total Me. of Progenesis: For TNT	Principal Liss: Excervation, demolition, and cratering Method of Londing: Hall Packer machine loaded
For Subject HE	Looding Density: gm/cc 0.9
Frequency Valuality: ft/sec At 9 ft At 25½ ft Density, gm/cc	Tamped cartridge 1-1/2" diameter, 8" long Storege:
Blast (Relative to THT):	Method Dry Hazard Class (Quantity-Distance) Class 9
Air: Peak Pressure Impulse Energy	Compotibility Group Group A Exudation
Ale, Confined: Impulse	Sensitivity to Initiation:Stick dry, No. 6 Electric capStick dry, Corps of ElegineersStick wet, Corps of EngineersPositive
Under Weter: Peak Pressure Impulse	Air Gap Propagation: Max distance will, inch 2-1/2 min distance will not, inch 3
Eneryy	Stick Water Immersion:           Weight gein, \$         9-16
Undergraund: Peak Pressure Impulse Energy	Heat of:       625         Cost Volume, cc/gm       611         Cold Storage:       Plastic to -65°F         Low Temperature Usage:       1000
	-65°F, 1 day, M2 cap crimper Satisfactory

### AMCP 706-177

#### Dynamite, Low Velocity, Picatinny Arsenal (LWD)

#### Preparation:

To date this dynamite has been prepared on a laboratory scale, the details of which are classified. It has been shown, however, to be machine loadable on a Hall packing machine.

#### Origin:

MAN THE WAY WAY

Hobel invented the original dynamite in 1866 and gave the name dynamite to mixtures of nitroglycerin and kieselguhr. The strength of a dynamite was indicated by the percentage of H3 in the mixture. Later oridants and combustibles were substituted for the kieselguhr, and ammonium nitrate and/or nitrostarch replaced the H3, bringing into existence new types of dynamites. World War II military operations required special demolition and crate ing explosives free from the objectionable characteristics of H3 and many "dynamite substitutes" were developed for specific applications. The subject low velocity dynamite was developed in 1956 by Picatimy Arsen() (Ref a).

#### References: 25

(a) H. W. Vuigt, <u>Development of Low-Velocity Military Explosives Equivalent to Commercial</u> <u>Dynamites</u>, PA Technical Report 2374, March 1957.

(b) Also see the following Picutiumy Arsenal Technical Reports on Dynamites:

<u>0</u>	1	2	<u>4</u>	٤	<u>6</u>	ĩ	<u>8</u>	2
1260 1360 1720 1760	1 <b>381</b> 1611	782 153:	864 1464	1285	1416 1436 1506 2056	507 957	848 1828	1819

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<sup>25</sup>See footnote 1, page 10.

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### Dynamite, Medium Velocity, Hercules (MVD)

AMCP 706-177

Composition:	Melecular Weight:	
	Oxygen Belence:	
100 75 1977 15	CO <sub>2</sub> %	-51
	CO %	
8tarch 5 SNE No. 10 011	Density: gm/cc Loading	1.1
Vistanex oil gel* 1	Todatug	1.1
80/15/5, SAE No. 10 weight oil/Vistanex B- 120XC/Mavy D2 wax,	Making Paint: *C	
C/H Rotio	Freezing Point: "C	
Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm >100	Nitroglycerin Equivalent,	\$ 60
Sample Wt 20 mg 18	Refrective Indix, ng	
Picatinny Arsenal Apparatus, in. 25	ng	
Sample Wt, mg	ng	
Edular Deschlar Text		
Friction Pendulum Tout:	Vecuum Stebility Teet:	
Steel Shoe Crackles	cc/40 Hrs, at	
Fiber Shoe Unaffected	90°C	
Rife Ballat Impact Test: Trials	- 100°C	0.80
%	120°C	0.94
Explosions C	135°C	
Partials 0	150°C	
Burned 10	200 Grem Bemb Send Test:	
Uno/fected 90	Sond, gm	52.6
Explusion Temperature: *C	Someitivity to 1 altistics:	
Seconds, 0.1 (no cop used)	Minimum Detonating Charge, gm	
1	Marcury Fulminate	
5		0.00
10		0.20
15	Tetryl	0.10
20	Ballistic Mortor, % TNT:	122
·····	Tread Test, % TNT:	
75°C International Heat Test:	Plate Dant Test:	
% Loss in 48 Hrs	Method	
100°C Heat Test:	Condition	
% Loss, 1st 48 Hrs 0.62	Confined	
% Loss, 2nd 48 Hrs 0.12	Density, gm/cc	
	Brisches, % TNT	
Explosion in 100 Hrs None		
Flammstillty Index:	Eletenstion Rate:     Confinement	None
		None
Hygrescepicity: %		schine tamped
71°C, 95% RH, 30 days Satisfactory	Charge Diameter, in.	1.50
	Density, gm/cc	1.1

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#### AMCP 706-177

### Dynamite, Medium Velocity, Herculas (MVD)

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Fregmentation Test:	Shaped Charge Effectiveness, TXT = 109:
90 mm HE, M71 Projectile, Let WC-91:	Glass Cones Staal Cones
Density, gm/cc	Hole Volume
Chorge Wt, Ib	Hole Depth
Total No. of Fregments:	Column Date of the second seco
For TNT	Color: Buff
For Subject HE	
	Principal Uses: Excavation, demolition, and
3 inch NE, MAZA1 Projectile, Let KC-5:	cratering
Density, gm/cc	
Charge Wt, Ib	
Total No. of Fragments:	Adathed of Longham Holly Ducham madding Analysis
For TNT	Method of Loading: Hall Packer machine loaded
For Subject HE	
	Leading Density: gm/cc 1.1
	Cartridge 1-1/2" diameter, 8" long
Fregment Velocity: ft/sec	
At 9 ft At 25% ft	Storege:
Density, can/cc	
	Method Dry
·	
Diest (Relative to TNT):	Hazard Class (Quantity-Distance) CLass 9
Ain	Compatibility Group Group A
Peak Pressure	Provide Alexandre
Impulse	Exudation
Energy	
	Sensitivity to Initiation:
Air, Confined: Impulse	Stick dry, No. 6 Electric cap Positive Stick dry, Corps of Engineers Positive
	Stick wet, Corps of
Under Water:	Engineers > 50% Positive
Peak Pressure	Air Gap Propagation:
Impulse	Max distance will, inch 1
Energy	Min distance will not, inch 2-1/2
	Quarry Performance: 4 tons rock/ton
Vadarground:	explosive
Peak Pressure	Stick Water Immersion:
Impulse	Weight gain, % 25-27
Energy	Heat of: Explosion, cal/gm 935
	Ges Volume, cc/gm 945
	Cold Storage: Plastic to -70°F
	Low Temperature Usage: -65°F, 1 day, M2 cap
	crimper Satisfactory

#### Dynamite, Medium Velocity, Hercules (MVD)

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#### Preparation:

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Manufactured on standard dynamite line and packaged on a Hall packing machine. Details of handling materials and techniques of manufacture are classified.

#### Origin:

Military forces frequently require excavition, demolition, and cratering operations for which standard high explosives are unsuitable. Commercial blasting explosives, except black powder, are called dynamites although they may contain no nitroglycerin. The subject dynamite substitute was developed in 1952 by the Hercules Powder Company (Ref a).

#### References: 26

(a) W. R. Baldwin, Jr., <u>Blasting Explosives (Dynamite Substitute)</u>, Hercules Powder Company Formal Progress Report, RI 2006, 15 August 1952, Army Contract DA-36-034-0RD-110.

(b) H. W. Voigt, <u>Development of Low-Velocity Military Explosives Equivalent to Commercial</u> <u>Dynamites</u>, PA Technical Report No. 2374, March 1957.

<sup>26</sup>See footnote 1, page 10.

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### EC Blank Fire

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Composition: 96	Molecular Weight: Approximately 503
Nitrocellulose, 13.25% N 80	Oxygen Selence:
Barium Nitrate 8 Potassium Nitrate 8	CC <sub>2</sub> % +5 CO % -25
Starch 3	
Diphenylamine 0.75 Aurine 0.25	Density: gm/cc
	Making Point: "C
C/H Ratie	Freezing Point: "C
Import Sensitivity, 2 Kg Wt:	Boiling Point: "C
Bureau of Mines Apparatus, cm 19 Sample Wt 20 mg	Refrective Index, ng
Picatinny Arsenal Apparatus, in.	no.
Sample Wt, mg 20	r 125 7. 50
Friction Pendulum Test:	Vocuum Stability Test:
Steel Shoe Shaps Fiber Shoe	cc/40 Hrs, at 90°C
	100°C
Rifle Bullet Import Test: Trials	120°C
~ %	135°C
Explosions	150°C
Partials	
Burned	200 Grem Domb Sand Test:
Unaffected	Sand, gm 46.8
Explosion Temperature: °C	Sensitivity to Initiation:
Seconds, 0.1 (no cop used)	Minimum Detonating Charge, gm
5 Decomposes 200	Mercury Fulminate 0.22
10	Lead Azide
15	Tet;yl
20	Sallistic Mortar, % TNT:
<b>7</b>	Treuzi Test, % TNT:
75°C International Heat Test: % Loss in 48 Hrs 1.8	Plate Dent Test:
	Method Condition
100°C Heat Test:	Confined
% Loss, 1st 48 Hrs 2.0	Density, gm, "cc
% Loss, 2nd 48 Hrs 0.2	Brisance, % TNT
Explosion in 100 Hrs None	
	Detenation Rate:
flow-mobility index.	
Flammability Index:	Confinement
-	Condition
Fismmebility Index: Hygrescepicity: % 30°C, 90% RH 6.2	

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Fragmentation Test:	Shaped Chorge Effectivenese, THT = 1	<b>99</b> 2
90 mm HE, M71 Projectile, Let WC-91:	Glass Conce Steel	Cones
Density, gm/cc	Hole Volume	
Chorge Wt, Ib	Hole Depth	
Total No. of Fragmants:	Color:	
For TNT		
For Subject HE	Principel Uses: Grensdes; caliber	.30 blank
3 inch NE, M42A1 Projectile, Let KC-5:		
Density, gm/cc		
Chorge Wt, Ib		
Total No. of Fragments:	Mether of Looding:	Loose
For TNT	•	
For Subject HE	Loading Density: gm/cc	0.40
Fragment Velocity: ft/sec		
At 9 ft	`	
At 251/2 ft	Sierage:	
Density, gm/cc	Method	Wet
Biest (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 0
Airz	Compatibility Group	Group J
Peak Pressure	Exudation	
Impulse		
Enorgy		
Air, Confined: Impulse	Preparation: EC Blank Fire is a colloided propellant manufac cess using either acetone an mixture of butyl acetate and	tured by a pro- d ethanol or a
Under Water:	gelatinize only a part of th	
Peak Pressure	lose. The process is contro the product passes through a	
Impulse	and is retained on a No. 50	
Exergy	Origin:	
Underground:	Invented in 1882 as bulk spo	
Peak Pressure	less) powder by W. F. Reid and the Explosive Company (whence t	
Imputse Energy	in England (Eritish Patent 619)	
References: 27(a) See the following Picatinny	120°C Heat Test:	Minutes
Arsenal Technical Reports on EC Blank Fire: 891, 001 372 512 822 233 1373 854 65 667	Selmon Pink	150
901, 372, 512, 822, 233, 1373, 854, 65, 667, 817, 69, 579 and 1399.	Red Fumes Explodes	300+ 300+

<sup>27</sup>See footnote 1, page 1C.

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### AMCP 706-177

### Ednatol, 55/45

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Composition:	Molecular Weight:	178
Haleite (Ethylene Dinitramine) 55	Oxygon Balance:	
• • • • • • • • • • • • • • • • • • • •	CO. %	-51 -17
TNT 45	CO %	-11
	Density: gm/cc Cast	1.62
	Molting Point: 'C Eutectic	80
C/H Rot State	Freezing Point: "C	
Impact Sanshivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 95	Boiling Polist: "C	
Sample Wt 20 mg Picatinny Arsenal Apparatus, in.	Refractive Index, No.	ļ
Sample Wt, mg 20	n	
	្ពុ ខ	
Friction Pendulum Text:	Vocuum Stability Test:	
Steel Shoe Unaffected	cc/40 Hrs, at	1
Fiber Shoe Unaffected	90°C	
Rifle Bullet Impact Test: Thats	- 100°C	1.0
%	120°C	11+
Explosions 0	135°C 150°C	
Partials 0	130 C	
Burned 7	200 Grew Bomb Sond Yest:	
Unaffected 93	Sand, gm	49.4
Explasion Temperature: * °C	Seashivity to Initiation:	
Seconds, 0.1 (no cap used): 435	Minimum Detonating Charge, gm	
1 248	Mercury Fulminate	0.22*
5 Decomposes 190	Leod Azide	0.26*
10 183 15 176	*Alternative initiating charg	ies.
15 176 20 168	Ballistic Mortus, % THT: (a)	119
*Composition Haleite/INT, 60/40.	Treuzi Test, % TNT: (b)	120
75°C International Heat Test:	Plate Deat Test:	52/48
% Loss in 48 Hrs	Method	52/40 B
	Condition	Cast
100°C Heat Test: % Loss, 1st 48 Hrs 0.2	Confined	No
· · · · · · · · · · · · · · · · · · ·	Density, gm/cc	1.62
	Brisance, % TNT	112
Explosion in TOU Hrs None		
Flammability index: Will not continue to burn	- Detenation Role: Confinement	None
	Condition	Cast
Hygrotsoyisity: % None	Charge Diameter, in.	1.0
	Density, gm/cc	1.63
Veletility:	Rate, meters/second	7340

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### Ednatol, 55/45

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90 mm HE, M71 Projectile,	Lot WC-91:		Glass Cones	Steel Cones
Density, gm/cc	1.56	1.62	Hole Volume 126	123
Charge Wt, Ib	2.065	2.092	Hole Depth 117	121
Total No. of Progments:				
For TNT	703	703	Color:	Yellow
Fox Subject HE	842	902	Principel Usus: Projecti	les, bombs; special
3 inch HE, MAZA1 Projectils	, Let KC-S:			on components
Density, gm/cc		1.60		
Charge Wt, Ib		0.845		
Total No. of Fragmants:				
For TNT		514	Mothod of Looding:	Cast
For Subject HE		536		
			Looding Density: gm/cc	1.65
regment Velecity: ft/sec At 9 ft		2730		······
At 251/2 ft		2430	Storego:	
Density, gm/cr		1.62	1 -	
·· • ·			Method	Dry
liast (Relative to TNT);		(d, e)	Hazard Class (Quantity-Dist	once) Class 9
Air:			Compatibility Group	Group I
Peak Pressure		108		
Impulse		110	Exudation 3	Does not exude at (
Energy		<b>10</b> 8		
Air, Confined:			Eutectic Temperature, °	<u>79.8</u>
Impulse			gm Haleite/100 gm TNT 79.8°C	0.48
			95.0°C	1.12
Under Weter: Peak Pressure			Compatibility with Metal	
			Dry: Brass, aluminum,	
Impulse		••	mild steel, mild steel of	coated with acid-
Energy		113	proof black paint, and a	mild steel plated
Underground:			with cadmium or nickel a per, magnesium, magnesium,	
Peak Pressure			mild steel plated with o	
Impulse			slightly affected.	
Energy			Wet: Copper, brass, a	
Booster Sensitivity Tes	t:	(â)	aluminum alloy, mild ste	el, mild steel cos
Condition		Cast	with acid-proof black pa	
Tetryl, gm War in fan 504 Detu	mu + 1	100	plated with copper, cadmare heavily attacked. A	
Wax, in. for 50% Deto Density, gm/cc	TRE LLON	1.28 1.62	affacted and stainless	

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### Ednatol, 95/45

#### Preparation:

Wet Haleite is added slowly to molton TWT heated at about 100°C in a steam jacketed melting kettle equipped with a stirrer. Heating and stirring are continued until all moisture is evaporated. Loading is done by pouring the mixture cooled to 85°C.

#### Origin:

Mixtures of Haleite (EINA) and TNT, designated Ednatol; were developed at Picatinny Arsenal just prior to World War II.

### References: 28

(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, <u>Part III - Miscellaneous</u> <u>Sensitivity Tests</u>; <u>Performance Tests</u>, <u>OSRD Report No. 5746</u>, 27 December 1945.

(b) Fhilip C. Keenan and Dorothy C. Pipes, <u>Table of Military High Explosives</u>, Second Revision, MAVORD Report No. 87-46, 26 July 1946.

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for Tetryl in Boosters</u>, NDL Memo 10,303, 15 June 1949.

(e) W. R. Tomlinson, Jr., <u>Blast Effects of Bomb Explosives</u>, PA Tech Div Lecture, 9 April 1948.

(f) Eastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Sec III, Variation of <u>Cavity Effect with Composition</u>, NDRC Contract W-672-ORD-5723.

(g) Bastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Final Report, 18 September 1943, NERC Contract W-672-ORD-5723.

(h) Also see the following Picatinny Arsenal Technical Reports on Eduatol:

<u>o</u>	<u>1</u>	2	. 3	<u>4</u>	2	<u>6</u>	<u>7</u>	<u>8</u>	2
1290 1400 1420 1530	1291 1451 1651	1162 1372 1482	1193 1 <b>3</b> 63 1493	1294 1434	1325 1395 1885	1796	1457 1477 1737 1797	1198 1388 1838	1 <b>27</b> 9 1469

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28See footnote 1, page 10.

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Ethylene Glycol Di-Trinitrobutyrate (GTNB)

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Composition: %	Molecular Weight: (C10H12R6016)	468
с 25.6 н 2.6	Oxygen Belence: COz % CO %	<b>-34</b> 0
$\begin{array}{c} & & & \\ & & & \\ \mathbf{N} & 17.1 \end{array}$	Density: gm/cc Crystal	1.63
о 54.7 сн <sub>2</sub> со <sub>2</sub> сн <sub>2</sub> сн <sub>2</sub> с(мо <sub>3</sub> )	Molting Point: *C	,96
C/H Ratio 0.235	Freezing Paint: *C	
Impost Sausitivity, 2 Kg Wt:	Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg	Refractive Index, No. No. No.	
Friction Pondulum Test: Steel Shoe Fiber Shoe	Vecuum Stability Test: cc/40 Hrs, at 90°C	
<b>Rifio Sullet Import Test:</b> Trians % Explosions Portials	100°C 120°C 135°C 150°C	
Burned Unaffected	200 Grem Bomb Sond Test: Sand, gm	
Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 5 50% point 230 10 15	Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryl	<u> </u>
20	Ballistic Morter, % TNT:	
75°C International Heat Test: % Loss in 48 Hrs	Treuzi Test, % TNT: Plate Dant Test: Method	
199°C Heet Test: % Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs Explosion in 100 Hrs	Condition Confined Density, gm/cc Brisonce, % TNT	
Flemmebility Index:	Detenation Rate: Confinement	
Hygroscopicity: %	Condition Charge Diameter, in.	
Veletility:	Density, gm/cc	1.63 7 <b>340</b>

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### Ethylene Glycol Di-Trinitrobutyrete (GTNB)

Fregmentation Test:	Shaped Charge Effectiveness, TNT = 100;			
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth Celer:			
Total No. of Fragmants: For TNT				
For Subject HE 3 lach HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, No	Principal Uses: Casting madium for HE compounds			
Tutol No. of Fragments: For TNT For Subject HE	Method of Looding: Cast			
	Loading Deusity: gm/cc 1.60			
Fregment Velocity: fr/sec At 9 ft At 25½ ft Density, gm/cc	Storege:			
Blast (Relative to THT):	Method Dry — Hazard Class (Quantity-Distance)			
Air: Peak Pressure Impulse	Compatibility Group Exudation None			
Energy Air, Confined: Impulse	<u>Preparation:</u> (a) By the addition of nitroform to ethylene			
Under Weter: Peak Pressure Impulse	glycol diacrylate. As the method of prepa- ration often leads to products difficult to purify, a preparation from ethylene glycol and pure trinitrobutyric acid is in process.			
Energy	Origin:			
Underground: Peak Pressure Impulse	First synthesized in 1951 by the U.S. Rubber Company, Research and Development General Laboratories, Passaic, New Jersey.			
Energy	Viscosity, poises:			
	Temp, 98.9 <sup>0</sup> C 0.246 106.5 <sup>0</sup> C 0.193			
	Liquid Density, gm/cc: Temp, 98.9°C 1.467 106.5°C 1.459			

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#### Ethylene Glycol Di-Trinitrobutyrate (GTNB)

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#### References:29

<sup>29</sup>See footnote 1, page 10.

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(a) U. S. Rubber Company Progress Report No. 14, Navy Contract Nord-10129, 1 February 1951 to 1 May 1951.

(b) U. S. Naval Ordnance Laboratory, Silver Spring, Maryland, Letter from Dr. O. H. Johnson to Commanding Officer, Picatinny Arsenal, 8 April 1955 (ORDEB 471.86/44-3, Registry No. 39815); and MOL Letter from Dr. D. V. Sickman to Commanding Officer, Picatinny Arsenal, 29 November 1955 (ORDEB 471.86/159-1; Serial No. 32894).

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### Explosive D (Ammonium Picrate)

Composition:	Meleculer Weight: (CGHGN407)	246
$\frac{96}{C}$ C 29.3 $0-MH_{1}$ H 2.4 $0_{2}N$ N $0_{2}$	Cuyger Belanco: CO <sub>2</sub> % CO %	-52 -13
N 22.7	Bensity: gm/cc Crystal	1.72
0 45.6	Mobing Point: "C Decomposes	265
C/H Ratio 0.317	Freesing Point: *C	
mpact Sanshivity, 2 Kg Wt:	Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	Refrective Index, ne a <sub>o</sub>	1. 508
Picatinny Arsenal Appavatus, in. 17 Sample Wt, mg 18	bo	1.870
	°	1.907
viction PenAulum Test:	Vector Stebility Test:	
Steel Sho Unaffected	cc/40 Hrs, at	
Fiber Shoe Guarrected	90°C	
Lifie Bullet Import Test: Trials		0.2
%	120°C 135°C	0.4
Explosions 0	135°C 150°C	0.4
Portials 0		<b>V</b> 17
Burned 30	290 Grem Sumb Send Test:	
Unoffected 70	Sand, gm	39.5
Explosion Temperature: *C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used) 405	Minimum Detonating Charge, gm	
1 367	Mercury Fulminate	
5 Decomposes 318 10 314	Leod Azide	0.20
15 299	Tetryl	0.06
20 295	Bellistic Morter, % TNT: (a)	99
	Treuzi Teit, % TNT:	
<ul> <li>*C International Heat Test:</li> <li>% Loss in 48 Hrs</li> </ul>	Plate Dant Test:	
72 LUBS (FL 40) F1F3	Method	A
00°C Heat Test:	Condition	Pressed
% Lnss, 1st 48 Hrs 0.1	Confined	Yes
% Loss, 2nd 48 Hrs 0.1	Density, gm/cc	1.50
Explosion in 100 Hrs None	Brisance, % TNT	91
·	Detenation Rate:	
Summability Index:	Confinement	None
	Condition	Pressed
tygrescepicity: % 100% RH 0.1	Charge Diameter, in.	1.0
Voletility:	Density, gm/cc	1.55
/ etertainy i	Rate, meters/second	6850

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## Explosive D (Annonium Picreta)

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Progmoniation Test:		Shaped Charge Effectivences, TNT :	= 109:
90 mm HE, M71 Projectile, Lat	WC-93:	Glass Corres Ste	el Cones
Density, gm/cc	1.50	Hole Volume	
Charge Wt, Ib	1.94	Hale Depth	
Total No. of Fragments:		Celer	(ellow-orange
For TNT	703		
For Subject ME	649	Principal Uses: AP projectile	s and bombs
3 inch HE, M42A1 Projectile, Le	* KC-5:		
Density, gm/cc	1.55		
Charge Wt, Ib	0.82		
<b>-</b> .	0.02		
Total No. of Progments:		Method of Londing:	Pressed
For TNT	514		
For Subject HE	508	Looding Density: gm/cc PSi X	103
		Leeding Density; gm/cc P\$1 x 3 5 10 12	15 20
Fregment Velocity: ft/sec		1.33 1.41 1.47 1.49	1.51 1.53
At 9 ft At 25½ ft		Storogs:	
Density, gm/cc		Method	Dry
Blast (Relative to THT);		Hazard Class (Quantity-Distance)	Class 9
Air: F vok. Pressure		Compatibility Group	Group I
Impulse		Exudation No.	one at 65°C
•			
Energy			
Air, Confined: Impulse		Sensitivity to Electrostatic Discharge, Joules:	(d)
		Through 100 Mesh:	
Under Weter:		Confined	6.0
Peak Pressure		Unconfined	0.025
Impulse			
Energy		Booster Sensitivity Test:	(c)
		Condition	Pressed 100
Underground:		Tetryl, gm Wax, in. for 50% Detonat	
Peak Pressure		Density, gm/cc	1.54
Impulse		Heat of:	÷
Energy			2690
		Combustion, csl/gm Explosion, csl/gm	800
		Formation, cal/gm	395
			<del></del>
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### AMCP 706-177

### Explosive D (Ammonium Picrate)

### Preparation:

Explosive D is manufactured by suspending picric acid in hot water and neutralizing it with gaseous or liquid ammonia. As the picrate is formed, it goes into solution; on cooling, it precipitates. An excess of ammonia leads to formation of the red form of ammonium picrate. This should be avoided. The separated crystals are washed with cold water and dried.

## Effect of Storage on Sand Test Values:

		Minimum Detonating Charge				
Stor Years	<u>e</u>	Mercury Fulminate (gm)	<u>Tetryl</u> (gm)	Sand Crushed (gm)		
0 3.5 2 * 4 * 2 **	50 Normal Normal 50	0.25	0.06 0.03 0.04	23 23 23 23 23		

\* After 3.5 years at 50°C.
 \*\* After 3.5 years at 50°C and 2 years at magazine temperature.

### Solubility: gm/100 gm (\$), of: (e)

Water		4	lcohol	Ethyl Acetate		
°c	٤	°c	· £	°c	£	
20	1.1	0	0.515	0	0.290	
100	75	10	0.690	10 .	0.300	
		. 30	1.050	30	0.380	
		50	1.890	50	0.450	
		80	3.620	80	0.560	

### Origin:

First prepared by Marchand in 1841 and used by Brugere in admixture with potassium nitrate as a propellant in 1869. Used as a high explosive after 1900.

### Destruction by Chemical Decomposition:

Explosive D (annonium picrate) is decomposed by dissolving in 30 times its weight of a solution made from 1 part of sodium sulfide ( $Na_2S^{-}9H_2O$ ) in 6 parts of water.

### References: 30

(e) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, Part III - Miscellaneous Sensitivity Tests; <u>Performance Tests</u>, OSRD Report No. 5746, 27 December 1945.

30See footnote 1, page 10.

## Explosive D (Annonium Picrete)

### AMCP 706-177

1:19

(b) D. P. MacDougall, Methods of Physical Testing, OGRD Report No. 803, 11 August 1942.

(c) L. C. Smith and S. R. Welton, <u>A Consideration of PDX/Wax Mixtures as a Substitute for Tetryl in Boosters</u>, JL News 10, 303, 15 June 1989.

(d) F. W. Brown, D. H. Musler and F. C. Gibson, <u>Sensitivity of Explosives to Initiation</u> by <u>Electrostatic Discharges</u>, U. S. Dept of Int, Bureau of Mines, RI 3852, 1946.

(e) Various sources in the open literature.

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- in the second 
(f) Also see the following Picatinny Arsenal Technical Reports on Explosive D:

<u>o</u>	1	2	3	<u>4</u>	٤	. <u>6</u>	ĩ	<u>8</u>	2
340 870 1380	1441 35 1	132 582 1172 1352 1372 1492	843	694 704 874 1234 1724	65 425 1585 1655 1725 1885 1895	266 556 796 986 1466 1796	1737 1797	328 836 1838	1 <b>729</b> 1 <b>75</b> 9

i ani Maria

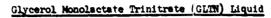
## AMCP 706-177

### Glycerol Monolactate trinitrate (GLTN) Liquid

Composition: %	Melecular Weight: (C6H9N3011)	299
C 24.1 0 0N02	Oxygen Bolence: CO2 %	-30
	CO %	3
	Density: gm/cc Liquid	1.47
CH ONO	Maiting Paint: "C	
0 58.8		
C/H Ratio 0.180	Freezing Point: "C	
Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 15 (1 1b vt); 42	Boiling Point: "C	
Sample Wt 20 mg Picatinny Arsenal Apparatus, in.	Refrective Index, no	
Sample Wt, mg	nat	1.464
	ne	
Friction Pand in Test:	Vacuum Stability Test:	
Steel Shoe Unaffected	cc/40 Hrs, at	
Fiber Shoe Unaffected	90°C	
Rifle Bullet Import Test: Trials		5.9
%	135°C	
Explosions	155°C	1
Partials	130 C	
Burned	200 Gram Bamb Sand Test:	ļ
Unaffected	Sand, gm	13.1
Explosion Temporature: 'C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)	Mininum Detonating Charge, gm	
1 5 223	Mercury Fulminate	
5 223 10	Lood Azide	
15	Tetryi	
20	Ballistic Marter, % ThiT:	
	_ Troubl Tost, % THT:	
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Test:	
	Method	
109°C Heat Test:	Condition	
% Loss, 1st 48 Hrs 2.5	Confined	
% Loss, 2nd 48 Hrs 1.8	Density, gm/cc	
Explosion in 100 Hrs None	Brisonce, % TNT	
Finmsbillty Index:	- Detenstion Rate:	ł
repaired by the car	Confinement	
Hygrescepicity: %	- Condition	1
	Charge Diameter, in.	
Veletility: 60°C, mg/cm <sup>2</sup> /hr 28	Density, gm/cc	
	Rate, meters/second	

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Fregmentation Test:	Shaped Clearge Effectiveness, TNT =	199:
98 mm HE, M71 Projectile, Let WC-91:	Glass Cones Steel	Cones ·
Density, gm/cc	Hole Volume	
Charge Wt, Ib	Hole Depth	
Tatel No. of Fregments:	Celer:	
For TNI		
For Subject HE	Principal Uses: Gelatinizer for n	itrocellulos
3 inch HE, M42A1 Projectile, Let KC-5:		
Density, gm/cc		
Chorge Wt, Ib		
Total No. of Fragments: For TNT	Method of Londing:	
For Subject HE		
	Loading Dansity: gm/cc	
Fregment Velocity: ft/sec		
At 9 ft At 25¼ ft	Storege:	
Density, gm/cc		
	Method	Liquid
Blast (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 9
Air:	Compatibility Group	
Peok Pressure		
Impulse	Exudation	
Energy		
Air, Confinet:	Hydrolysis, % Acid:	
Impulse	10 days at 22°C	0.021
·	5 days at 60°C	0.014
Under Weter:	Solubility in Water,	
Peak Pressure	<u>gm/100 gm, at:</u>	
Impulse	2:5°C (60°C	<0.01 <0.015
Energy		40.019
Madama wada	Solubility, gm/100 gm, at 25°C, in:	
Underground: Peak Pressure		_
Impulse	Ether 2:1 Ether:Alcohol	80 10
Energy	Acetone	•
	Heat of:	
	Combustion, cal/gm	2407

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### Glycerol Monolactate Trinitrate (GLTM) Liquid

### Preparation:

Glycerol monolactate (GML) is prepared by heating a glycerol lactic acid mixture containing 45 excess lactic acid at  $116^{\circ}$ C for 112 hours with dry air bubbling through the liquid. The product which contains 0.67% free acid is carefully mixed with 6 parts of 40/60 HMO<sub>3</sub>/H<sub>2</sub>SO<sub>4</sub> maintained at 20°C, stirred for 1 hour, cooled to 5°C, and poured on ice. It is extracted with ether, water-washed, adjusted to pH 7 by shaking with a sodium bicerbonate solution, and again water-washed that the times. It is then dried with calcium chloride, filtered and freed of ether by bubbling with air until minimal loss in weight is obtained. The product has a nitrate-nitrogen contact of 13.43% (theoretical 14.1% N). Another batch, prepared from GML obtained from glycerol-lactic acid containing 6.5% excess glycerol, had a nitrate-nitrogen content of 14.30%, corresponding to a mixture containing 5.5% nitroglycerin. It is not considered practicable to prepare the pure GLTN.

#### Origin:

The preparation of a nitrated ester of lactic acid and glycerol, by nitrating a glyceryl lactate with nitric and sulfuric acids, for use in explosives, was reported in 1931 by Charles Stine and Charles Burke (U. S. Patent 1,792,515).

The preparation of glycerol monolactate by heating glycerol with equimolar proportions of a lactic acid ester of an alcohol boiling below 100°C (ethyl lactate) was patented by Richie H. Locke in 1936 (British Patent 456,525 end U. S. Patent 2,087,980).

## Reference: 31

(a) P. F. Macy and A. A. Saffitz, <u>Explosive Plasticizers for Nitrocellulose</u>, FATR No. 1616, 22 July 1946.

<sup>31</sup>See footnote 1, page 10.

## Glycol Dinitrate (GDN) Liquid

AMCP 706-177

Compasition: %	Melecular Weight: (C2 <sup>H</sup> 4 <sup>N</sup> 2 <sup>O</sup> 6)	152			
c 15.8 _ ONO <sub>2</sub>	Oxygen Belance:				
	CO <sub>2</sub> % CO %	0.0 21			
<b>v v c b</b>	Brensity: gm/cc Liquid, 25°C	: 1.48			
0 63.2	Melting Point: "C	-20			
C/H Rotio 0.092	Freezing Point: *C	······································			
Impact Sensitivity, 2 Kg Wt:	Solling Point: "C	· · · · ·			
Bureau of Mines Apparatus, cm 4 (1 1b vt); 56 Sample Wt 20 mg	Refrective Index, na				
Picatinny Arsenal Apparatus, in.	ngo ngo	2 1.1.50			
Sample Wt, mg		1.4452			
Friction Pendulum Test:	Vocuum Stability Test:				
Steel Shoe	cc/40 Hrs, at				
Fiber Shoe	90°C				
Rifle Sullet Impect Test: Trials	120°C				
%	135°C				
Explosions	150°C				
Portiols					
Burned	200 Gram Bomb Sand Test:				
Unaffected	Sand, gm				
Explosion Temperature: °C	Sensitivity to Initiation:				
Seconds, 0.1 (nc cop used)	Minimum Detonating Charge, g	m			
) 5. Theology 05%	Mercury Fulminate				
5 Evplodes 257	Lead Azide				
10	Tetryl				
15 20	Ballistic Morter, % TNT:				
<u>دي</u>	Trouzi Test, % TNT:	·····			
75°C International Heat Test:	Plate Deat Test:				
% Loss in 48 Hrs	Method				
100°C Heet Test:	Condition				
% Loss, 1st 48 Hrs	Confined				
% Loss, 2nd 48 Hrs	Density, gm/cc				
Explosion in 100 Hrs	Brisance, % TNT				
	Betersetien Beter				
Flemmebility Index:	Confinement	Glass tube			
	Condition	Liquid			
Hygrescepicity: % 30°C, 90% RH 0.00	Charge Diameter, in.	10			
	Density, gm/cc	1.485			
Velatility:	and the second s	*****			

## AMCP 706-177

## Glycol Dinitrate (GDN) Liquid

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Fragmentation Test:	Shaped Charge Effectiveness, TNT = 100:
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth
Total No. of Fregmants: For TNT	Color: Yellow
For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc	Principel Uses: Ingredient of nonfreezing dynamite
Chorge Wt, Ib Total inc. of Fragmonts:	Method of Loading:
For TNT For Subject HE	Leading Density: gm/cc
Fragment Valocity: ft/sec At 9 ft At 25½ ft	Storage:
Density, gm/cc	Method Liquid
Blast (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9
Air: Peck Pressure Impulse Energy	Compatibility Group Exudation
Air, Conflaed: Impulse	Solubility in 1000 cc Water:         Temp, °C       Grams         15       6.2
Under Weter: Peok Pressure Impulse	20 6.8 50 9.2 Viscosity, centipoises:
Energy	Temp, 20°C 4.2 Varor Pressure:
Undergreund: Peak Pressure Impulse	OC     mm Mercury       0     0.0044
Impulse Energy	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
	Heat of: Combustion, cal/gm 1764 Formation, cal/gm (b) 366

<u>Glycol Dinitrate (GDN) Liquid</u>

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### Preparation:

Glycol dinitrate (ethylene glycol dinitrate, dinitroglycol, nitroglycol, dinitrodimethyleneglycol) may be prepared by nitration of ethylene glycol, HOCH2CH2OH, with a mixed nitric acid in the same apparatus that is used for the preparation of nitroglycerin. The glycol is prepared by synthesis from ethylene, and ethylene chlorohydrin:

 $CH_2 = CH_2 \xrightarrow{HOC1} HOCH_2CH_2C1 \xrightarrow{H_2O} HOCH_2CH_2OH$ 

### Origin:

Henry was the first to prepare and identify glycol dinitrate (Ber 3, 529 (1870) and Ann chim phys [4] 27, 243 (1872) but Kekulé had previously nitrated ethylene and obtained an unstable oil which he supposed to be glycol nitrate-nitrate. No immediate practical use was inde of glycol dinitrate because glycol itself was relatively rare and expensive at the time. It was 1904 before a patent was granted covering the use of GDN as an explosive (DRP 179,789). but it was seven years later before its actual use as an explosive was recorded (Mám poudr <u>16</u> (1911) p. 214). The principal physical properties of GDN were determined or recorded by Rinkenbach (Ref b).

## References: 32

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(a) Ph. Naoum, <u>Nitroglycerin and Nitroglycerin Explosives</u>, translation, E. M. Symmes, The Williams and Wilkins Company, Baltimore (1928), p. 224.

(b) Wm. H. Rinkenbach, "The Properties of Glycol Dinitrate," Ind Eng Chem 18, 1195 (1926).

(c) Wm. H. Rinkenbach, "Glycol Dinitrate in Dynamite Manufacture," Chem Met Eng, <u>34</u>, 296 (1927).

(d) Wm. H. Rinkenbach, Application of the Vacuum Stability Test to Nitroglycerin and Nitroglycerin Explosives, PATR 1624, 27 August 1946.

32See footnote 1, page 10.

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<u>н-6</u>

Composition: 96	Molecular Weight:	93
RDX 45	Oxygen Selence:	
TTT 30	CO. %	-66
Aluminum 20	CO %	- 36
<b>D-2 Wax</b> 5	Density: gm/cc Cast	: 1.74
Calcium Chloride, added 0.5	Molting Point: °C	
C/H Ratio	Freezing Point: "C	
It meet Sensitivity, 2 Kg Wt:	Boiling Point: "C	
Bureou of Mines Apparatus, cm	Refrective Index, no	
Picatinny Arsenal Apparatus, in. (c) 14 Sample Wt. ma 18	n	
Sample Wt, mg 18	n	
Friction Pendulum Test:	Vecuum Stability Test:	
Steel Shoe Unaffected	cc/40 Hrs, at	
Fiber Shoe	90°C	
Pitta Bullin Inners Para	- 100°C	0.47
Rifie Bullet Impect Test: Trials (b)	120°C	
% Explosions 80	135°C	
Partials	150°C	
Burned	200 Grem Bemb Send Test:	
Unoffected 20	Sand, gm	49.5
Explosion Tomperature: °C (a)	Sensitivity to Initiation:	
Seconds, 0.1 (no cop used)	Minimum Detonating Charge, gm	
1	Mercury Fulminate	
5 610(min) (c)	Lead Azide	0.20
10	Tetry!	0.10
15 20	Bellistic Morter, % TNT: (d)	135
	Trouzi Test, % TNT:	
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Test:	
100°C Heat Test:	Condition	
% Loss, 1st 48 Hrs 0.78	Confined	
% Loss, 1st 46 m/s 0-10 % Loss, 2nd 48 m/s 0-00	Density, gm/cc	
	Brisance, % TNT	i
Explosion in 190 Hrs None	- Dates stion Rate:	
Flommability Index:	Confinement	(a, b) None
	- Condition	Cast
Hygrescepicky: % 30°C, 95% RH, 7 days 2.01 71°C, 95% RH, 7 days 1.77	Charge Diamster, in.	1.0
71°C, 95% RH, 7 days 1.77		
	Density, gm/cc	1.71 [

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<u>H-6</u>

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Beaster Sensitivity Test:		Decemposition Equation:
Condition		Oxygen, atoms/sec
Tetryi, gm		(Z/sec)
Wax, in. for 50% Detanation		Heat, kilocalorie/mole
Wax, gm		(ΔH, kcal/mol) Temperature Range, *C
Density, gm/cc		Phase
Heat of:	2070	Armor Plete Import Test:
Combustion, col/gm	3972	
Explosion, cal/gm	923	60 mm Mortur Projectile:
Gas Volume, cc/gm	733	50% Inert, Velocity, ft/sec
Formation, cal/gm	_	Aluminum Fineness
Fusion, col/gm 18°C (b)	10.25	
Receille Martine		500-16 General Purpose Bombe:
Specific Heat: c_,, jm/°C	(b)	Plate Thickness, inches
30 <sup>0</sup> C	0.269	
50 <sup>0</sup> C	0.268	1
		114
		11/2
	<u></u>	13/
Burning Rote:		
cm/sec		Bomb Drop Test:
Thermel Conductivity:	(b) <sub>-3</sub>	
cal/sec/cm/°C 35°C	1.10 × 10 <sup>-5</sup>	T7, 2000-16 Semi-Armor-Piercing Bomb vs Concrete:
Coefficient of Expansion:		Max Safe Drcp, ft
Linear, Al/inch	. h	500-16 General Purpose Bamb vs Concrete:
0 <sup>0</sup> C 35 <sup>0</sup> C	$40 \times 10^{-4}$ 83 x 10^{-4}	
35°C 70°C	$83 \times 10^{-1}$ 131 x 10 <sup>-1</sup>	Height, ft
		- Trials
Mardness; Mohs' Scale:		Unaffected
Yawaala Maduluu.	(>)	Low Order
Yevag's Modulus;	(b) 9.0 x 10 <sup>9</sup> 5	High Order
E', dynes/cm²	$4.30 \times 10^{5}$	
E, Ib/inch <sup>2</sup>	2.71	1000-16 Goneral Purpose Bomb vs Concrete:
Density, gm/cc		
Compressive Strength: Ib/isch2	See beicw	- Height, ft Triale
	Dee Derow	Trials
	· · · · · · · · · · · · · · · · · · ·	Unaffected
Vapor Pressure: *C mm Mercury		Low Order
C mm Mercury	2	High Order
Compressive Strength: 1b/incl		
Density, gm/cc	1.71	
Ultimate deformation, %	1.32	

## AMCP 706-177

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Fragmentation Test:	(b)	Shoped Charge Effectiveness, TNT = 1	<b>100</b> :
90 mm HE, M71 Projectile, Lot ECS-1-1	17:	Glass Cones Steel	Cones
Density, gm/cc		Hole Volume	
Charge Wt, Ib		Hole Depth	
'Total No. of Fragments:		Color:	Gray
For Composition B	998		Gray
For Subject HE For 30/20 Tritonal	714 616	Principsi Uses:	HE charge
3 inch HE, MAZA1 Projectile, Lot KC-5:			
Density, gm/cc			
Charge Wt, Ib			
Total Ko. of Fragments:		Method of Londing:	Cast
For TNT For Subject HE		-	
		Leading Density: gm/cc	1.71
Fregment Velocity: ft/sec			
At 9 ft At 25½ ft		Storega:	
Density, gm/cc		-	
··· •		Method	Dry
Sinut (Rolativa to TNT):	(a)	Hazard Class (Quantity-Distance)	<b>Class</b> 9
Air: 3.25" diameter sphere		Compatibility Group	Group I
Peok Pressure & pai Catenary	25.4		
impulse NFOC Pendulum	19.8	Exudation	None
Energy			
Air, Confined: Impulse			
Under Weter: Peak Pressure			
Impulse		}	
Energy			
Underground: Peak Pressure			
Impulse			
Energy			
Impulse			

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## <u>H-6</u>

## Effect of Altitude, Charge Diameter and Degree of Confinement on Det mation Velocity\*

(Reference e)						
	1		h Column		h Column	
Explosive	Simulated Altitude, Feet	Confined m/s	Unconfined m/s	Confined m/s	Unconfined m/s	
TRT,	Ground	6820	6720	6670	5270	
density, gm/cc 1.59	30,000	6660	6930(2)	6610	6760(4)	
	60,000	6800	<b>.</b> .	6520	6400(4)	
	90,000	6810	6720	6550	6610(1)	
Average	1	67,98	6790	6588	6260	
B-6,	Ground	7190	7360	7340	6870	
density, gm/cc 1.69	. 30,000	7300(2)	7430	7360	7980	
_, _,	60,000	7280	7490	7550	7010	
	90,000	7300(3)	7270	7500	7000	
Average		7268	7385	7438	7215	

\*Confined charge in 1/4" steel tube, AISI 1015 seamless, 1" diameter 18" long, and 2" dismeter 7" long. All means were determined from sets of five values unless otherwise indicated by ( ). A 26 gm tetryl booster was used to initiate each charge.

		Sir			
Explosive	Charge Diameter, Inches	Ground m/s	<u>30,000</u> m/s	<u>60,000</u> n/s	<u>90,000</u> m/s
INT,	1	2940	2991	3119	2868
density, gm/cc 1.51	2	3623	4191	5077	4980
H-6,	1	3461	3405	3467	5563
density, gm/cc 1.71	2	4603	4726	4998	5288

#### Average Fragment Velocities at Various Altitudes\* (e)

\*Outside diameter 2.54"; inside \*tameter 2.04"; length 7".

### References:

See HEX-1; HEX-3 reference list.

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## AMCP 706-177

## Haleite (Ethylene Dinitramine) (EDNA)

Composition:		Molecular Weight: (C2H6ii)	.°4) 150
%; С 16.0 н	~ ~ <sup>NO</sup> 2	Oxygon Balance:	
н 4.0	2 <sup>c</sup> — N	CO. % CO %	-32 -10.5
	H	Density: gm/cc Crystal	
м 37.3 0 42.7 н	 2 <sup>c</sup> n < <sup>NO</sup> 2 H	Atoling Point: "C Decompo	
C/H Ratio 0.066	2 <sup>c</sup> — M H	Freezing Point: "C	
mpact Sensit? '+v, 2 Kg Wt:		Boiling Point: °C	- <u>11 </u>
Bureau of ines Apparatu Sample Wt 20 mg	s, cm 48	Refractive Indax, no	
Picatinny Arsenal Appara			
Sample Wt, mg	17	n <sup>0</sup>	
riction Pendulum Test:		Vecuum Stability Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	A
Lifle Bulict Impact Test:	Trials	100°C 120°C	0.5
-	%	135°C	1.5
Explosions	0	150°C	'
Portiols Burned	60		LLT
Durned Unaffected	20 20	200 Grem Bomb Sand Test: Sand, gm	52.3
	 •c		
Explosion Temperature: Seconds, 0.1 (no cap used		Sensitivity to initiation: Minimum Detonating Charg	ae am
1	216	Mercury Fulminate	0.21
5 Decomposes		Lead Azide	0.13
10	178	Tetryl	••
15	173	Bellistic Morter, % TNT:	(2) 100
20	170		(a) 139 (b) 122
5°C International Heat Test			(c)
% Loss in 48 Hrs	0.01	Method	A
50°C Heat Test:		Condition	Pressed
% Loss, 1st 48 Hirs	0.2	Confined	Үев
% Loss, 2nd 48 Hrs	0.3	Density, gm/cc	1.50
Explosion in 100 Hrs	None	Brisance, % TNT	122
len mebility Index:	0	Detonation Rate:	
THE COUNTY INCOMES:	138	Cunfinement	Unconfined
lygrescopicity: %	0.01	Condition	Pressed
	·····	Charge Diameter, in.	1.0
Voletility:	Nil	Density, gm, cc	1.49

## 

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Booster Sensitivity Test: Condition	(d) P <b>re</b> ssed	Decomposition Equation: (e) (e) (f) Oxygen, atoms/sec 10 <sup>12.8</sup> 10 <sup>12.1</sup> 10 <sup>1</sup>
Tetryi, grn	100	(Z/sec)
Wax, in. for 50% Detonation	2.09	Heat, kilocalorie/mole 30.5 37.3 30.0
Wax, am		(ΔH, kco!/mci) Temperature Range, °C 184-254 144-10
Density, gm/cc	1.42	Phose Liquid Solid Solid
Haet of: Combustion, cal/gm	2477	Armor Plate Impact Test:
Explosion, cal/cm	1276	
Gas Volume, cc/gm	908	60 mm Morter Projectile:
Formation, cal/gm	134	50% Inert, Velocity, ft/sec
	134	Aluminum Fineness
Fusion, cal/gm		500-th General Purpose Bosabs:
Specific Hest: cal/gm/°C		Plate Thickness, inches
		1
		11/2
		<sub>14</sub> 4
Surning Rote: cm/sec		
		Somb Drop Test:
Thermel Conductivity: col/sec/crn/*C		17, 2000-Ib Semi-Armor-Piercing Bomb vs Concrete:
Coefficient of Expansion:		Max Safe Drop, ft
Linear, %/°C		500-16 General Purpose Bomb vs Concrete:
Volume, %/°C		Height, ft
· · · · · · · · ·		Triols
Hordmas, Mohs' Scale:		Unaffected
		Low Order
Young's Modulus:		High Order
E', dynes/cm²		
E. Ib/inch <sup>2</sup>		1000-Ib General Purpose Bamb vs Concrete;
Density, gm/cc		
		Height, ft
Compressive Strength: Ib/inch <sup>2</sup>		Trials
	<u> </u>	Unoffected
Vapor Pressure:		Low Order
°C mm Mercury		High Order

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10.00

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## Haleite (bthylene Dinitramine) (EDNA)

•

Charge Wt, ib Hold Total No. of Fregmants: For TNT For Subject HE Princip 3 Inch HE, M42A1 Projectile, Lee NC-5: Density, gm/cc 1.50 Charge Wt, ib Tetel No. of Fregmants: For TNT 514 For Subject HE 600 Leedin Fregmant Velecity: ft/soc At 9 ft At 25½ ft Density, gm/cc Met Blast (Relative to TNT): Hold Hol	Gloss Cones Steel Cones lole Volume lole Depth m: White cipel Uses: Booster
For TNT     For Subject HE       3 inch HE, M42A1 Projectile, Lee MC-5: Density, gm/cc     Princip       Density, gm/cc     95/5 Imleito/vax       Charge Wt, Ib        Tetul Ne. of Prognants:     Metho       For TNT     514       For Subject HE     600       Leadin     5       Prognant Velecity: ft/soc     5       At 9 ft     5       At 25½ ft     Storug       Blast (Relative to TNT):     Haz	
3 inch HE, M42A1 Projectile, Lee KC-5: Density, gm/cc     95/5 Bileite/vex 1.56       Charge Wt, Ib        Tetel No. of Prognosts:     Metho       For TNT     514       For Subject HE     600       Fregment Velecity: ft/soc     5       At 9 ft     5       Density, gm/cc     Metho       Blast (Relative to TNT):     Hoz	cipsi Uses: Booster
For TNT     514       For Subject HE     600       Frequence Velocity: ft/soc     1.28       At 9 ft     1.28       At 25½ ft     Storage       Density, gm/cc     Met       Blant (Relative to TNT):     Hoz       Air:     Com	
Frequency Velocity: ft/soc     5       At 9 ft     1.28       At 25½ ft     Storegy       Density, gm/cc     Met       Blast (Relative to TNT):     Hoz       Air:     Con	hed of Looding: Pressed
Air: Corr	28 1.38 1.41 1.44 1.49
	azard Class (Quantity-Distance) Class 9 ompatibility Group
Impulse Exur Energy: Air, Confined: Impulse	kudation None
Under Water: Peok Tressure Impulse Energy	
Underground: Peak Pressure Impulse Energy	

### Haleite (Ethylene Dinitramine) (EDNA)

AMCP 706-177

### Compatibility with Metals:

<u>Dry</u> - Copper, brass, aluminum, mild steel, stainless steel, mild steel coated with acidproof black paint, and mild steel plated with copper nickel, cadmium or zinc are unaffected. Magnesium and magnesium-aluminum alloy are slightly affected.

Net - Copper, brass, mild steel coated with acid-proof black paint, and mild steel plated with copper, cadmium, nickel or zinc are heavily corroded. Aluminum is slightly affected and stainless steel is unaffected.

### Impact Sensitivities of Various Crystal Habits:

Bureau of Mines	Impact	Test;	2 Kg Wt:
Habit			<u>8</u>
lst plate 2nd plate Bi-pyramid Bracydome Sphenoid			55 55 71 66 46

### Solubility: gm/100 gm (\$) of:

Mater		Alo	coho].
°c	ž	°c	ž
20 40 60 80 100	0.25 0.75 2.13 6.38	20 40 60 78	1.00 2.46 5.29 10.4

### Preparation:

2

(Summary Technical Report of the NDRC, Div 8, Vol 1)

$$\begin{array}{c} \mathrm{CH}_{2}\mathrm{O} + \mathrm{HCN} \rightarrow \mathrm{HO} \ \mathrm{CH}_{2}\mathrm{CX} \\ (98\% \ \mathrm{yield}) \\ \mathrm{HO} \ \mathrm{CH}_{2}\mathrm{CN} + \mathrm{NH}_{3} \rightarrow \mathrm{NH}_{2}\mathrm{CH}_{2}\mathrm{CN} + \mathrm{H}_{2}\mathrm{O} \\ (82\% \ \mathrm{yield}) \\ \end{array}$$
$$\begin{array}{c} \mathrm{NH}_{2}\mathrm{CH}_{2}\mathrm{CR} + 2\mathrm{H}_{2} \rightarrow \mathrm{H}_{2}\mathrm{N} \ \mathrm{CH}_{2}\mathrm{CH}_{2}\mathrm{NH}_{2} \end{array}$$

(88% yield)

$$\begin{array}{c} cH_2 & - NH_2 \\ | \\ cH_2 & - NH_2 \end{array} + cO_2 \rightarrow \begin{array}{c} cH_2 & - NH \\ | \\ cH_2 & - NH_2 \end{array} \right) cO + H_2O$$

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### Haleite (Ethylene Dinitramine) (EDNA)

<sup>CH</sup>2  $^{\mathrm{CH}}_{+2}$ - NH . CH2-N - NO2 -N -NC2 - co + 2HNO3 -≥co + 2મ<sub>2</sub>0 сн<sub>2</sub>-N=NO2 CH2-N-N02 - NH ' CH2  $CH_2 - NH - NO_2$ + co<sub>2</sub> CH\_\_\_\_NH --\_ NO\_2 The raw materials used in this process are cheap and available; the first three reactions

The raw materials used in this process are cheap and available; the first three reactions proceed smoothly, rapidly and in good yield (70% overall), and only the third requires high pressures. The reaction of ethylenediamine with carbon dioxide at about  $220^{\circ}C$  and 820 atmospheres has been worked out and is more satisfactory for the preparation of ethyleneurea than the use of chlorethyl carbonate or urea and better than the reaction of acetic anhydride and ethylenediamine to yield N,N'-diacetyl-ethylenediamine which can be treated in a way similar to the above to yield Haleite.

Ethyleneurea is very easily nitrated, with strong mitric acid (98%). at ordinary temperature, and in a very short time, and the dinitroethyleneurea produced appears to approximity, yielding Haleite, immediately after solution in water at 95°C. Both the mitration and hydrolyeis are practically quantitative.

### Origin:

First described in 1877 by Franchimont and Klobbie (Rec trav chim 7, 17 and 244) but it vas 1935 before its value as an explosive was recognized. Standardized during World War II as a military explosive.

### Destruction by Chemical Decomposition:

Haleite is decomposed by addition to hot, dilute sulfuric acid. Nitrous oxide, acetaldehyde and thylene glycol are evolved. Haleite is also decomposed by addition to 5 times its weight of 20% sodium hydroxide.

## References: 33

(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, Part III - Miscellaneous <u>Sensitivity Tests</u>; <u>Performance Tests</u>, <u>OSRD Report No. 5745</u>, 27 December 1945.

(t) Report AC-2983/Org Ex 179.

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> Tetryl in Boosters, NOL Memo 10,303, 15 June 1949.

(e) R. J. Finkelstein and G. Gamow, <u>Theory of the Detonation Process</u>, NAVORD Report No. 90-46, 20 April 1947.

(f) M. A. Cook and M. Taylor Abbeg, "Isothermal Decomposition of Explosives." University of Utah, <u>Ind Eng Chem</u> (June 1956) pp. 1090-1095.

33 ee footnot: 1, page 10.

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### Haleite (Ethylene Dinitramine) (EDNA)

( $\varepsilon$ ) Also see the following Picatinny Arsenal Technical Reports on Haleite:

<u>o</u>	1	2	3	4	٤	<u>6</u>	<u>7</u>	<u>8</u>	2
1200 1290 1360 1380 1400	12 <b>31</b> 1451 1651	1162 1232 1252 1352 1372	1113 1493 1923	414 1294 1434	1255 1325 1395 1885	786 1796	897 1737 1797 1937	1198 1288 1378 1388 1838	1279 1319 1379 1469 1489

## AMCP 706-177

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Composition:		Molecular Weight:	102
%5 RDX 40		Oxygen Bolence:	
TNT 38		CO, %	-68
Aluminum 17		CO %	- 35
D-2 Wex 5		Density: gm/cc Cast	1.72
Calcium Chloride, added 0.5		Matting Point: "C	
C/H Ratio		Freezing Point: *C	
mpoct Sonsitivity, 2 Kg Wt:		Boiling Point: *C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg		Refrective Index, ng	
Picatinny Arsenal Apparatus, ir		nas	
Sample Wt, mg	21	ns	
Friction Pendulum Test: (b)		Vocuum Stubility Test:	(a, b)
Steel Shoe	Unaffected	cc/40 Hrs, at	, ., ., .,
Fiber Shoe		90°C	
			0.47
Rifle Bullet Impoct Test: Trial		120°C	0.98
% Explosions 73		135°C	
Explosions 73 Partials		150°C	11+
		200 Green Bomb Send Test:	
Burned Unoffected 28		Sand, gm	48.1
	C (a)	Sensitivity to Initiation: Minimum Detonating Charge, gm	
		Mercury Fulminate	
	480	Lead Azide	0.20
10		Tetryl	0.10
15			133
20			
75°C Internatis at Test:		Treuzi Test, % TNT:	
% Loss in 48		Plate Dent Test: Method	
	(-)	Condition	
	(b)	Confined	
100°C Hest Test:	0.059	1	
% Loss, 1st 48 Hrs	0.058	Density, gm/cc	
% Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs	0.00		
% Loss, 1st 48 Hrs	•	Brisonce, % TNT	(e h)
% Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs Explosion in 100 Hrs	0.00	Brisonce, % TNT Detenction Rate:	(a, b) None
% Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs Explosion in 100 Hrs Flemmebility Index:	0.00 None	Brisance, % TNT — Detenction Rate: Confinement	None
% Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs Explosion in 100 Hrs Flemmebility Index: Myerescenicity: % 30 <sup>0</sup> C, 95% R	0.00 None H, 7 days 2.98	Brisonce, % TNT — Detenstion Rate: Confinement — Condition Charge Diameter in	None Cast
% Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs Explosion in 100 Hrs	0.00 None H, 7 days 2.98	Brisonce, % TNT — Detenstion Rate: Confinement — Condition Charge Diameter in	None

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AMCP 706-177 HBX-1 (c) Cast **Beester Sensitivity Test:** Dece nposition Equation: Oxygen, atoms/sec (Z/sec) Condition 100 Tetryl, gm Heat, kilocalorie/mole Wax, in. for 50% Detonation 1.25 (ΔH, kca mol) Temperature Range, °C Wax, gm Density, gm/cc 1.73 Phase (b) 3882 Heat of: Armor Plate Impoct Test: Combustion, cal/gm Explosion, cai/gm **91**9 **60 mm Morter Projectile:** Gas Volume, cc/gm 50% Inert, Velocity, ft/sec 758 Formation, cal/gm Aluminum Fineness Fusion, col/gm 78°C 9.25 500-lb General Purpose Bombs: Specific Heat: cal/gm/°C (b) Plate Thickness, inches 30°r 0.249 50°C 0.264 1 1411/2 134 Burning Rote: cm/sec **Bomb Drop Test:** Thermel Conductivity: cal/sec/cm/\*C 35°C (b) 0.97 x 10-3 T7, 2090-ib Semi-Armoz-Piercing Bomb vs Concrete: Coefficient of Expansion: Lingor, ALAnch OC 35°C 70°C Max Safe Drop, ft (b)  $46 \times 10^{-4}$ 95 × 10 159 × 10^{-4} 500-16 General Purpose Bomb vs Concrete: Height, ft Trials Herdness, Mohs' Scale: Unoffected Low Order (b) Young's Medulus: High Order 10.3 x 10<sup>9</sup> E', dynes/cm² 1.49 x 10<sup>-5</sup> E, Ib/inch<sup>2</sup> 1000-lb General Purpose BomL vs Concrete: 1.69 Density, gm/cc Height, ft Compressive Strength: Ib/inch<sup>2</sup> See below Trials Unaffected Veper Pressure: \*C Low Order mm Mercury High Order (b) 1303 1.69 1.38 Compressive Strength: lt/inch<sup>2</sup> Density, gm/cc Ultimate deformation, %

## AMCP 706-177

HBX-1

Freemuntation Test:	(b)	Shaped Charge Effectiveness, TNT =	100:
90 mm NE, M71 Projectile, Lot EGS-1	-17:	Glass Cones Steel	Cones
Density, gm/cc	•	Hole Volume	
Charge Wt, Ib		Hole Depth	
Tetal No. of Fregments:			
For Composition B	998	Celer:	Gray
For Subject HE	910		
For 80/20 Tritonal	516	Principal Uses:	HE charge
3 inch HE, M42A1 Projectile, Let KC-5:			
Density, gm/cc			
Charge ½t, Ib			(
Total No. of Fragments:		Method of Looding:	Cast
For TNT			
For Subject HE			
Fregment Velocity: ft/sec		Looding Density: gm/cc	1.69
At 9 ft		·	
At 251/2 ft		Storage:	
Density, gm/cc		Method	Dry
Bloot (Relative to TNT):	(e)	Hozard Class (Quantity-Distance)	Class 9
Air: 3.25" diameter sphere		Compatibility Group	Group I
Peck Pressure & psi Catenary NFOC Pendulum	24.7 19.6		
Imputse	-	Exudation	None
Energy			
Air, Coefined: Impulse			
Under Weter: Peak Pressure			
Impulse		1	
Energy			
Underground:			Ì
Peak Pressure Impulse			
Energy			
C 41 97			

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<u>HBX-3</u> AMCP 706-177 Compo % aition : Molecular Weight: 64 Oxygen Belence: CO<sub>2</sub> % CO % RDX 31 -75 -49 TNT 29 Aluminum 35 1.84 Density: gm/cc D-2 Wax Cast 5 Calcium Chloride, Melting Point: 'C 0.5 added C/H Ratio Freezing Print: \*C Impact Sensitivity, 2 Kg Wt: **Boiling Point: \***C Bureau of Mines Apparatus, cm --Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Refrective Index, na 15 n25 Sample Wt, mg 23 n<sub>at</sub> Friction Pendulum Test: (a, b) Vecuum Stebility Test: cc/40 Hrs, at 90°C Steel Shoe Unaffected Fiber Shoe -------100°C 0.45 Rifle Buildt Imprict Test: (b) Trials 120°C **%** 78 135°C Explosions 150°C **Partials** --Burned --(Ъ) 44.9 200 Gram Bamb Sand Test: 22 Unaffected Sand, gm Explosion Temperature: Sonsitivity to Initiation: ۰C **(a)** Seconds, 0.1 (no cop used) ---Minimum Detonating Charge, gm 1 Mercury Fulminate ----5 500 Lead Azide 0.20 10 Tetryl 0.10 15 Ballistic Morter, % TNT: (d) 111 20 Trougi Test, % TNT: 75°C International Heat Test: Piste Dent Test: % Loss in 48 Hrs Method Condition 107°C Heat Test: (b) Confined % Loss, 1st 48 Hirs 0.70 Density, gm/cc % Loss, 2nd 48 Hrs 0.00 Brisonce, % TNT Explosion in 100 Hrs None **Detenation Rate:** (a, b) Flammebility Index: Confinement None Condition Cast Hyg. cscopicity: % 30°C, 95% RH. 7 days (b) 71°C, 95% RH. 7 days 2.01 Charge Diameter, in. 1.0 0.31 1.81 Density, gm/cc Volatility: 6917 Rate, meters/second

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<u>HBX-3</u>

Beester Sensitivity Test: Condition		Decomposition Equation: Oxygen, atoms/sec	
Tetryl, gm		(Z/sec)	
Wax, in. for 50% Detonation		Heat, kilocalorie/mole (ΔH, kcol/mol)	
Wax, gm		Temperature Range, °C	ſ
Density, gm/cc		Phase	
Heat of: Combustion, cal/gm	(b) 4495	Armor Plate Impact Tait:	$\left  \right $
Explosion, cal/gm	877		
	011	60 mm Morter Projectile:	
Gas Volume, cc/gm	has	50% Inert, Velocity, ft/sec	
Formation, cal/gm	491	Aluminum Fineness	
Fusion, col/gm	9.30	500-lb General Purpose Bemba:	
Specific Hust: cal/gm/*C			
30°C	0.254	Plate Thickness, inches	
50° c	0.254	1	
		11/4	
		11/2	
		134	
Burning Rete: cm/sec		Bomb Drop Test:	-
Thermal Conductivity: cal/sec/cm/*C 35 <sup>0</sup> C	(b) 1.70 x 10 <sup>-3</sup>	T7, 2000-lb Semi-Armor-Piercing Bomb vs Concrete:	
Coefficient of Expension:	(b)	Max Safe Drop, ft	I.
Lineor, al/inch		500-lb General Purpose Bomb vs Concrete;	
0°C	40 x 10_1		
35°C 70°C	83 x 10 <sup>-4</sup>	Height, ft	
	130 x 10	Trials	
Hardness, Mohs' Scale:		Unaffected	
		Low Order	
Young's Modulus:	(b)		
E', dynes/cm²	11.5 x 10 <sup>9</sup>	High Order	
E, lb/inch <sup>2</sup>	1.67 x 10 <sup>5</sup>	1000-ib General Purpose Bomb vs Concrete:	1
Density, gm/cc	1.81		
Compressive Strength: Ib/inch <sup>2</sup>	Gee below	Height, ft	
Annhiere suendur: 10/ lucu.	DEE DETOM	Trials	
	· · · · · · · · · · · · · · · · · · ·	Unaffected	{
Vapor Pressure:		Low Order	
°C mm Mercury		High Order	
( Ampressive Strength: 1b/inch <sup>2</sup>	1610		1
Density, gm/cc	1.81		1
Ultimate deformation, 🗊	1.37		

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ALC: NO

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HBX-3

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AMC: 70-177

Fregmentation Test:		Shapad Charge Effectivenese, TNT =	100:
9) mm H8, M71 Projectile, Let EGS=1=: Density, gm/cc Charge Wt, ib	17:	Glass Cones Steel Hole Volume Hole Depth	Cones
Total No. of Fregments: For Composition B	998	Color:	Gre;
Fr Subject HE Fr 80/20 Tritonal	476 616	Principal Uses:	HE charge
3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, lb			
Total No. of Fragments: For TNT For Subject HE		Method of Looding:	Cast
		Losding Density: gm/cc	1.81
Stegment Velocity: ft/sec At 9 ft At 25½ ft		Storoge:	
Density, gm/cc		Method	Dry
Blast (Relative to TNT):	(a)	Hazard Slass (Quantity-Distance)	Class 9
Air: 3.25" diameter sphere Pack Pressure A psi Catenary Impulse NFOC Pendulum	25.5 20.6	Compatibility Group Exudation	Group I None
Cnergy			
Air, Confined: Impulse	4.		
Under Weter: Peok Pressure	•		
Impulse Energy			
Underground: Pook Pressure			
Impulse Energy			

### AMCP 705-177

## HBX-1; HBX-3

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### The Stability of HEX Compositions Made With and Without Desiccants and Containing Added Moisture \*

	Moisture,	Acidity,	100°C Vac Steb Test		Hygroscopicity, %	
Explosive	E	E E	cc gas Hours		95% RH	
Composition		-			30°c	71°C
Standard HBX-1	0.73	0.011	0.47	40	+2.98	+1.13
+0.2% moisture	1		0.68	40		
+0.4% moisture	1		0.62	40		
+0.6% moiscure	1 I		0.50	40		
HBX-1 without CaClo	0.00	0.029	0.36	40	-0.06	-0.25
+0.2% moisture			0.25	40		
+0.4% moisture			0.23	40		
+0.6% moisture			0.27	40		
EX-1 with silica gel	0.06	0.031	0.73	40	+0.08	+0.04
Standard HBX-3	0.54	0.012	0.45	40	+2.01	+0.31
+0.25 moisture	0.)+	0.012	0.47	40	72.01	+0. JI
+0.45 moisture			0.43	40		
+0.6% moisture			0.41	40		
TO: UP BUISCUTE						
IBX-3 without CaCl	0.02	0.049	0.46	40	-0.06	-0.29
+0.2% moisture			0.26	40		
+0.4% moisture			0.26	40		
+0.6% moisture			0.20	40		
EX-3 with silica gel	0.04	0.100	0.45	40	+0.09	+0.05
Standard 3-6	0.71	0.017	0.47	40	+2.01	+1.77
+0.2% moisture		,	0.88	40		
+0.4% moisture			0.63	40		
+0.6% moisture			0.65	40		,
I-6 without CaClo	0.03	0.082	0.10	40	-0.06	-0.25
+0.2% moisture	0.03	0.002	0.10		-0.00	-0.25
+0.4% moisture				40 40		
+0.5% moisture			5.25			
TU. Up moisture			0.23	40		
I-6 with silics gel	0.05	0.028	0.43	40	+0.09	+0.06

\* All samples were ground to 20/100 mesh size, 7 days before tests. Silica gel used was Fisher vientific Company, Lot 541492, through 100 mesh U. S. Standard Sieve.

### HBX-1; HBX-3

AMCP 706-177

### Preparation:

HBX explosive mixtures are prepared by melting TNT in a steam-jacketed melt kettle equipped with a mechanical stirrer. Water-wet LDX is added slowly with stirring and heating until all the water is evaporated. Aluminum is added, and the composition is stirred until uniform. D-2 wax and calcium chloride are then added. The desensitizer wax, also known as Composition D-2, consists of 54% paraffin and other waxes, 14% nitrocellulose and 2% levithin. The mixture is cooled from approximately 95° to 100°C to a temperature considered suitable for casting (the lowest practicable pour temperature). HBX can also be made by adding the calculated amount of TWT to Composition B to outain the desired proportion of RDX/TNT. The appropriate weights of the other ingredients are added to complete the mixture.

### Origin:

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Developed during World War II, as relatively insensitive mixtures, by adding 5% desensitizer to Toroex II, for high blast explosive applications.

### References: 34

(a) O. E. Sheffield, Blast Properties of Explosives Containing Aluminum or Other Letal Additives, PATR No. 2353, November 1956.

(b) S. D. Stein, G. J. Horvat and O. E. Sheffield, Some Properties and Characteristics of HBX-1, HBX-3 and H-6, PATR No. 2431, June 1957.

(c) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> Tetryl in Boosters, NOL Memo. 10,303, 15 June 1949.

(d) S. R. Walton, <u>Report on the Program to Develop an Improved HBX-Type Explosive</u>, MAVORD Report No. 1502, 26 July 1950.

(e) A. W. O'Brien, Jr., C. W. Plummer, R. P. Woodburn and V. Philipchuk, <u>Detonation</u> <u>Velocity Determinations and Fragmert Velocity Determinations of Varied Explosive Systems</u> <u>and Conditions</u>, National Northern Corporation Final Summary Report NNC-F-13, February 1958 (Contract DAT-19-020-501-0KD-(P)-58).

(1) Also see the following Picatinny Arsenal Technical Reports on HBX Explosives: 1756, 2138, 2169.

34Ser footnote 1, page 10.

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Sec.

Contraction of the

<u>HEX-24</u>

Composition:		Molscular Weight:	47.6
% Potassium Perchlorate	32	Qxygen Belence:	
(17 microns)	-	CO <sub>2</sub> %	-42
Aluminum, atomized	48	CO %	- 34
(20 microns) RDX (through 325 mesh)	16	Presive an/20,000 psi	1.39 2.1
Asphaltum (through 100 mesh)	4	Melting Point: °C	
C/H Ratio		Freezing Point: "C	
Impact Sansitivity, 2 Kg Wt:		Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg		Refrective Index, no	
Picatinny Arsenal Apparatus, in.	16	ng	
Sample Wt, mg	24		
		n <sub>20</sub>	
Friction Pendulum Tust:		Vocuum Stability Test:	
Steel Shoe	Detonates	cc/40 Hrs, at	
Fiber Shoe	Unaff~cted	90°C	
Rifle Bullet Impact Test: Trials		- 100°C	1.25
King same impact ver: Trois		120°C	
>o Explosions		135°C	
Partials		150°C	
Burred		200 Gram Bomb Sand Test:	
Unaffected		Sand, gm	12.5
Explosion Temperature: °C		Sensitivity to Initiacion:	
Seconds, 0.1 1 " o used)		Minimum Detenating Charge, em	
1		Mercury Fulminate	
5 520		Lead Azide	0.20
10		Tetryl	0.25
15		Ballisia Martes & ThiT-	
20		Bellistic Monter, % TNT:	
75°C International Heat Test:		Plat, Dent Test:	
4 Loss in 46 Hrs		Method	
100°C Kest Test:		Condition	
% Loss, ist 48 Hrs	0.15	Confined	
% Loss, 2nd 48 Hrs	0.00	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TNT	
	-	Detonation Rate:	
Flemmability Index:		Confinement	
-		Condition	
Hygroscopicity: %	None	Charge Diameter, in.	
Volatišky:	None	Rate, meters/second	

Section .

c.	HEX-24 AMCP	706-17
Fragmentation Test:	Shaped Charge Effectivenese, TNT = 100:	
90 mm HE, M71 Projectile, Lot WC-91:	Glass Cones Steel Cones	
Density, gm/cc	Hole Volume	
Charge Wt, iø	Hole Depth	
Total No. of Fragments:		
For TNT	Color: Gray	
For Subject HE		
•	Principal Uses: HE filler for small calib	ber
3 inch HE, M42A1 Projectile, Lot XC-S:	projectiles	
Pensity, gm/cc		
Charge Wt, Ib		
Total No. of Fragmants:	Mathad at Loadbar	~~
For TNT	Method of Loading: Pressec	1
For Subject HE		
	Louding Density: gm/cc	
Fregment Velecity: ft/sec	Pressed at 20,000 psi 2.1	
At 9 ft	Stansara	
At 25½ ft Density, gm/cc	Storage:	
we satisfy Build of	Method Dry	
Blast (Relative to TNT):	Mazard Class (Quantity-Distance)	
Air:	Compatibility Group	
Peak Pressure		
Impulse	Exudation None	
Energy		
	Suatic Tests:	
Air, Confined: Impulse	20 mm T215El Projectile:	
	PA Peak Pressure, ps1 55 NFOC 20" Blast Cube 44	
Under Water:	APG 24" Blast Cube 44	
Peak Pressure	Static Tests:	
Impulse	20 mm M97 Projectile:	
Energy		2 C
Underground:	Catenary psi 46	3.0
Peak Pressure	Duration, microsec 533	
impulse	APG 24" Blast Cube 36 24	32
Energy	Heat of:	
lame Temperature, <sup>O</sup> K 255		
ctivation Energy, kcal 20.	Explosion, cal/gm 1858	
Temp, C 450 to 57	Ges volume, cc/gm 159	
Specific reaction		

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## AMCP 706-177

HEX-48
19996-40

Molecular Weight:	47.6			
Oxygen Balance:				
CO. %	-42			
CO %	- 34			
Density: gm/cc Apparent Pressed at 20,000 psi	0.69			
Metting Point: °C				
Fruezing Point: °C				
Boiling Point: °C				
Refractive Index, no				
-				
n <sub>30</sub>				
Vacuum Stability Test:				
cc/40 Hrs, at				
	1.52			
200 Gram Bomb Sand Test:				
Sand, gm	23.7			
Sensitivity to Iniviation:				
Minimum Detonating Charge, gm				
Mercury Fulminate				
Lead Azide	0.20			
Tetryi	0.25			
Bellistic Morter, % TNT:				
Trauzi Test, % TNT:				
Plate Dent Test:				
Method				
- Condition				
Confined				
Density, gm/cc	_			
Brisonce, % TNT	-			
Charge Diameter, in — Density, gm/cc				
	Oxygen Balance:         CO: %         CO: %         Density: gm/cc         Predised &: 20,000 ps1         Melting Point: °C         Fronzing Point: °C         Boiling Point: °C         Refrective Index, n%         n%         n%         N%         Vecuum Stability Test:         cc/40 Hrs, at         90°C         100°C         120°C         135°C         150°C         200 Grem Bomb Sand Test:         Sand, gm         Sensitivity to Inivistion:         Minimum Detonating Charge, gm         Mercury Fulminate         Lead Azide         Tetryi         Ballistic Morter, % TNT:         Plate Dent Test:         Method         Condition         Confined         Density, gm/cc			

farmer a



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Fragmentation Test:	Shaped Charge Filectiveness, TNT	= 1 <b>00</b> :
90 mm HE, M71 Projectile, Lot WC-91:	Glass Cones Si	eel Cones
Density, gm/cc	Hole Volume	
Charge Wt, Ib	Hole Depth	
Total No. of Fragments:	Color:	Grny
For TNT		•
For Subject HE	Principel Uses: HE filler for a projectiles	small caliber
3 inck HE, M42A1 Projectile, Lot KC-5:	projecties	
Density, gm/cc		
Charge Wt, Ib		
Totel No. of Fregments: For TNT	Method of Loeding:	Pressed
For Subject HE		
For Subjentite	Loeding Density: gm/cc	
	Pressed at 20,000	1.62
Fregment Valocity: ft/sec At 9 ft At 25½ ft	Storoge:	
Density, gm/cc	Method	Dry
Blast (Reletive to TNT):	Hazard Class (Quantity-Distanc	:e)
Air:	Compatibility Group	
Peak Pressure		Mana
Impulse	Exudation	None
Energy		
	Static Tests:	
Air, Confined:	20 mm T215El Projectile PA Peak Pressure, ps	
Impulse	NFOC 20" Blast Cube	45
Under Water:	APG 24" Elast Cube	42
Peak Pressure	Static Tests:	
Impulse	20 mm M97 Projectile: Hrx-40	THI Tetryl
Eneigy	Fostoro psi 17.3 Catenary psi 43	2.0 3.5 23 28
Underground: Peak Pressure	Duration, microsec 517 APG 24" Blast Cube 29	560 5 <b>30</b> 10
Impulse	Sent of	
Energy	liest of:	4119
Flame lemperature, <sup>O</sup> X 23"2	Prolosion, calim	1735
Activation merg., Keal 25.4	as Volume, read	200
(emp. 0.1.5.4.10		
rete. R 1.4 x 1.	a	

## AMCP 706-177

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## HEX-48

Cook-Off Tests: (c)

20 mm T215E1 HEY-48 Loaded Projectiles With Dye-Costed RDX Top-Off

Projectile No.	Cut-Off Temp. C	Cook-Off
1	170	Yes (198)
2	150	No
3	155	Yes (190)
4	150 to 175	No

### National Northern Projectile Load:

MOX-2B (no top-off)	195
MOX-2B (Tetryl top-off)	150
MOX-2B (97/3, RDX/wax top-off)	175
MOX-2 (no top-off)	175

Fragment Penetration Tests: (c)

			Avg. No. of Penetrations per Round in Zone 550-1300		
Projectile	Filler	Altitude, Feet	0.020"	0.040"	0.051"
T215E1	PEX-48	Ground	352	264	282
	:	60,000	676	432	388
<b>T282E1</b>	MOX-2B	Ground	634	290	235
:	:	60,000	807	367	250
EX8 Mod O M	MOX-2B	Ground	476	268	224
		60,000	672	264	256

The fragment penetration test records numbers of complete penetrations of aluminum panels of various thicknesses at 2.5 feet from the static detonation. The total penetrations recorded on the 24ST-3 aluminum panels occurred with the projectile nose always pointed toward C<sup>o</sup> and the base toward 180<sup>o</sup>.

The test data indicate that on the thicker panels, 0.040" and 0.051," the HEX-48 loaded T215E1 projectile produced more comple a fragment penetrations at ground and altitude than MOX-2B loaded T282E1 and EX8 Mod 0 projectiles.

HEX-24; HEX-48

AMCP 706-177

### Preparation:

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The HEX compositions were prepared by blending the appropriate weight of the dry ingredients in a Patterson-Kelly twin-shell blender for at least 30 minutes.

In alternate procedure for 100 to 200 gram batches used a "Cradle-Roll" mixing device. This device consisted of a half-barrel type container constructed of wood and lined with an electrical conductive material. A plastic roll was allowed to move over the ingredients by remote control action of the container. The roll action prevented caking of the mix but had no adverse effect on the particle size of the ingredients. The period of time required to obtained a uniform and intimate mixture was approximately fifteen minutes.

### Origin:

The development of "slow-burning" explosive mixtures which would produce increased blast effects in enclosed or nearly enclosed spaces directed attention to their use for possible military application. In 1950 Picatinny Arsenal developed a high capacity filler for 20mm projectiles consisting of 85/10/5 RDX/aluminum/desensitizer which was more powerful than standard tetryl filler. However, in comparison with MOX type explosives, there was little doubt as to the aperior performance of the MOX mixture. HEX (high pressive) mixtures were developed at Picatinny Arsenal in 1953 (Ref a) as superior high blact compositions suitable for use in small caliber projectiles.

### References: 35

(a) O. E. Sheffield and E. J. Murray, Development of Explosives---Metallized Explosives---High Blast Fillers for Small Caliber Shell, Picatinny Arsen 1 Memorandum Report No. MR-49, 21 December 1953.

(b) O. E. Sheffield, Properties of MOX-Type Explosive Mixtures, PATR No. 2205, October 1955.

(c) National Northern Corporation, Lewer from Dr. C. M. Saffer, Jr., to Commanding Officer, Picatinny Arsenal, 12 June  $195'_1$ 

<sup>35</sup>See footnote 1, page 10.

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## 2.4.0.2',4',6'-Hexanitro-oxanilide (ENC)

Composition: % S	Moleculor Weight: $(\mathbb{C}_{14}\mathbb{K}_6\mathbb{H}_9\mathbb{C}_{14})$
с 33.0 н 1.2 Nh Nh	Oxygen Balance:         -53.4           CO_ %         - 9.4
	Density: gm/cc
$\begin{array}{cccc} N & 21.9 & c_2 N \\ 0 & 43.9 \end{array}$	Melting Point: °C Decomposes 302
C/H Ratio 0.797 NO2	5. Freezing Point: "C
Impact Sensitivity, 2 Kg Wt:	Boiling Point: <sup>1</sup> C
Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 15 Sample Wt, mg 12	Refractive Index, n <sub>20</sub> n <sub>23</sub> n <sub>30</sub>
Friction Pendulum Test:	Vecuum Stability Test:
Steel Shoe         Unaffec           Fiber Shoe         Unaffec	ted cc/40 Hrs, at ted 90°C
Rifle Bullet Impact Test: Triais	100°C 0.40
% Explosions	135°C
Partials	150°C
Burned Unoffected	200 Gram Bomb Sand Test: Sand, gm 52-1
Explosion Temperature: "C Seconds, 0.1 (no cap used)	Sensitivity to Initiation: Minimum Detonating Charge, gm
1	Mercury Fulminate
<b>5</b> 384	Lead Azide 0.30
10	Tetryl 0.25
15 20	Ballistic Mortar, % TNT:
	Trauzi Test, % TNT:
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Test: Method
100°C Heet Test:	Condition
% Loss, 1st 48 Hrs 0.07	Confined
\$3 Loss, 2nd 48 Hrs 0.03	Density, gm/cc
Explosion in 100 Hrs IIone	Brisonce, % TNT
Flemmebility Index:	Confinement
Hygroscopicity: % 25°C, 90% PH 0.1	
Veletility:	Density, gm/cc Rate, meters/second

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### 2,4,6,2',4',0'-Hexanitro-oxanilide (HNO)

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Fragmentation Test:	ShapeJ Charge Effectiveness, TNT = 100:				
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth				
<b>Total No. of Fregments:</b> For TNT	Color: Almost white				
For Subject HE <b>3 inch HE, M42A</b> <sup>(*)</sup> Projectile, Lot KC-5: Density, gn <sup>++</sup> fac Charge Wt, -b	Principel Uses: Igniter powder; pyrotechnic compositions				
Total No. of Fragments: For TNT For Subject HE	Method of Looding: Pressed and extruded				
	Looding Density: gm/cc				
Fragment Velocity: ft/sec At 9 ft At 251/2 ft	Storage:				
Density, gm/cc	Method Dry				
Blast (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9				
Air: Peak Pressure Impulse	Compatibility Group Exudation None				
Energy Air, Confined: Impulse					
<b>Under Weter:</b> Peak Pressure Impulse					
Energy					
<b>Underground:</b> Peak Pressure					
Impulse Energy					

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2,4,6,2',4',6'-Hexanitro-oxanilide (HNO)

Solubility in the following substances:

### Solvent

Nitrobenzene	<3 gm in 100 cc, at $23^{\circ}C \sim 5$ gm in 100 cc, at $210^{\circ}C$	
Water	0.10 gm in 100 cc, at $100^{\circ}$ C	
Alcohol (Ethyl)	Insoluble	
Acetone	Insoluble	
Benzene	Insoluble	
Butyl acetate	Insoluble	
Carbon tetrachloride	Insoluble	
Dimethylformamide	Very soluble	
Ether (Ethyl)	Insoluble	
Acetic Acid	Insoluble	
Nitric Acid	Soluble	
Crystalline form	Long rectangular glistening plates from nitrobenzene	

### Preparation:

Nitr: Cryst

To prepare hexanitro-oxanilide, first prepare tetranitro-oxanilide as described herein under the entry "2,4,2',4'-Tetranitro-oxanilide (TNO)."

A 1.5 liter round bottom flask is equipped with a stirrer of the type which causes a downward swirt. The flask is jacketed for hot and cold water. 187 grams of nitric acid of specific gravity 1.49 (commercial grade) is placed into the flask and 100 grams of sulphuric acid is added to the nitric acid under agitation. The mixed acid is cooled to  $10^{\circ}$ C. 29.2 grams of tetranitro-oxmanilide is slowly added to the mixed acid under rapid agitation maintaining the temperature at 8°-10°C. After the addition of the TNG is completed (approximately 25 minutes) the temperature is raised to 85°C over a period of 2 hours and held at 85°-90°C for one hour. The hexanitro-oxmanilide (HNO) "slurry" is filtered on a Euchner funnel and purified as explained under "Tetranitro-oxmanilide."

### Origin:

A. G. Perkin in 1892 obtained hexanitro-oxanilide directly by heating to boiling a solution of tetranitro-oxanilide in a mixture of sulfuric and nitric acids. He also prepared the same compound from oxamilide by the action of a boiling mixture of fuming mitric and sulfuric acids (J Chem Soc <u>61</u>, 462 (1892)).

## References: 36

(a) L. Gowen and R. Dwiggens, <u>Case Gun Ignition Studies</u>, NAVORD Report No. 2321, 13 June 1952.

(b) D. Dubrow and J. Kristal, Substitution of Tetranitro Oxanilide and Hexanitro Oxanilide for Tetranitro Carbazole, PA Pyrotechnic Research Laboratory Report 54-TF1-85, 20 December 1954.

(c) S. Livingston, <u>Preparation of Tetranitro Carbazole</u>, PA Chemical Research Laboratory Report 136, 330, 11 April 1951.

(d) S. Livingston, Development of Improved Ignition Type Powders, PATE No. 2267, July 19 5.

36See footnote 1, page 10.

Sempesition:	Melecular Weight: (Ch H8N808) 296	
C 16.2 02N-N N-NO2	Onygen Belance:	
	CO. % -21 CO % 0	.6 .ა
	Density: gm/cc Crystal 1.9	
0 43.2 <sup>CH</sup> 2	Mobing Paint: *C Capillary method Koffer Micro Hot Stage	273
C/H Ratio 0.095	Francing Foint: *C	
Impact Sensitivity, 2 Kg Wt:	Boiling Point: *C	
Bureau of Mines Apparatus, cm 32 Somple Wt 20 mg	Refrective index, nº	
Picotinny Arsenal Apparatus, in. 9	na	
Sample Wt, mg 23	-	
Friction Pandulum Tast:	Vocuum Stability Test:	
Strei Shoe Explodes	cc/40 mis at	
Fiber Shoe Unaffected	90°C	
Rife Sullet Impact Test: Trials	100°C 0.3	
%	120°C 0.4	5
Explosions	135°C	
Pertials	150°C 0.64	?
8umed	200 Gram Bamb Sand Test:	
Unoffected	Sand, gm 60.4	ŀ
Explexion Temporature: *C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used) 380	Minimum Detonoting Charge, gm	
1	Mercury Futminate	
5 327	Lead Azide 0.30	)
10 306 15	Tetryl	
20	Ballistic Morter, % TNT: 150	·
	Trevel Test, % TNT: 145	
75°C International Gent Test: % Loss in 48 Hrs	Plate Dent Test:	
	Methor	
100°C Heat Test:	Condition	
% Loss, 1st 48 hrs 0.05	Confined	
% Loss, 2nd 48 Hrs 0.03	Dencity, gm/cc	
Explosion in 100 Hrs None	Brisonia, % TNT	
/commobility Index:	- Detenation Rate.	
	Confinament	
Nygroccopicity: %	Conditiun	
	Charge Diameter, in.	
30°C, 95% RH (c) 0.00	Density, gm/cc 1.64	

beta-HNG (a)

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beta-HNX

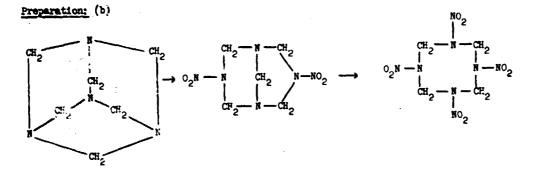
				· · · · · · · · · · · · · · · · · · ·
Condition			Decomposition Equation: Oxygen, atoms/sec	(•) 10 <sup>19.7</sup>
Tetryl, ym			(Z/sec) Heat, kilocoloria/mole	52.7
Wax, in. for 50% Detai	notion	`	(AH, kcol/msl)	
Wax, gm			Temperature Ronge, *C	271-314
Density, gm/cc			Phase	Liquid
Heat of: Combustian, cal/gm		23t.`	Armer Plate Impact Test:	
Explosion, col/gm	(e)	1356		
Gas Voiume, cc/gm			<b>60 mm Morter Projectile:</b> 50% Inert, Velocity, ft/sec	
Formation, cal/gm	(e)	-60.5	Aluminum Fineness	
Fusion, col/gm				
			S00-16 General Purpose Bembs:	
Specific Heet: cal/gm/*C		stallized		
° <u>c</u>	<u>°c</u>		Plate Thickness, inches	
-75 0.153	85	0.288		
0 0.228 25 0.243	90 100	0.290 0.295	1	
50 0.266	125	0.307	134	
75 0.282	150	0.315	11/2	
			1%	
Burning Bate: cm/sec				
			Bomb Drep Test:	
Thermel Conductivity: col/sec/cm/*C			T7, 2000-b Sami-Armer-Plarcing	Bomb vs Concrete:
Coefficient of Expension:			Max Sate Drop, ft	
Linear, %/°C			300-16 General Purpose Samb vs	Cencrete:
Volume, %/*C			Height, ít	
Hardman, Mohe' Scole:	(e)	2.3	Trials	
***************************************	(4)	<b>c</b> • j	Unaffected	
Young's Medulus:			Low Order	
E', dynas/cm <sup>2</sup>			High Order	
E, It/inch				Con and a
Density, gm/cc			indiate Gandrat Purpose South vi	Con trare:
Comprasive Strength: Ib/i	inch <sup>z</sup>		Trials	Į
			Unaffected	
Veper Pressure:			Low Order	
	Mercury		High Order	
		-	and the second se	

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beta-HMX

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Two men are required to regulate the addition of reagents and control the temperature during the initial stage addition; one win can complete the procedure. A 1-liter 5-necked flask is used, the center neck for an efficient stirrer, one side neck for a thermometer, and the other necks for burrettes and a gas outlet (to water trap). The flask is placed in a pan with steam and cold water inlets, for temperature control.

Five cc of acetic anhydride and 250 cc glacial acetic acid are poured into the flask and the temperature brought to  $45 \pm 1^{\circ}$ C, and held there for the duration of the entire reaction. The reagents (a solution of 33.6 gm hexamine in 55 gm of glacial acetic acid, 100 cc of acetic anhydride ard 40 cc of a solution of 42.3/57.7-ammonium nitrate/98% nitric acid) are then added simultaneously, continuously and equivalently over a 25-minute period. The reaction mixture is aged 15 minutes.

The second stage reagents (60 cc of 42.3/57.7, annonium nitrate/98% nitric acid and 150 cc acetic anhydride) are then added simultaneously, continuously and equivalently over a 25-minute period. The mixture is aged 65 minutes, poured into 1.5 liter of water and simulated on a stream bath for 12 hours. Cool, filter and dry the RDX-HMX precipitate (yield 73% HMX).

The HDK is destroyed, leaving HDK, as follows: 1025 gm of the crude product are placed in a solution of 15 gm sodium tetraborate decahydrate in 5 liters of water, heated to boiling with agitation, and 5 N HaOH added at the rate of 3 cc/min. When about 730 cc have been added the pH increases sharply from a little over 8.7 to over 9.7 which corresponds to complete destruction of the WDM. Filter the HOK from the hot mixture; yield 612 gm, mp 279.5°-280.5°C. Recrystallization from nitromethane yields material melting at 281°-282°C.

#### Origin:

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Was discovered as an impurity (by-product) in the nitration of hexamethylene-tetramine to form REX. It is now manufactured directly by the process described above and has valuable use in employieve systems.

Removal of RDX from H5X-97X Mixtures and Recovery of a RDX-H5X Mixture (This procedure appears suitable for use with mixtures containing 80% or more H5X);

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#### beta-HNX

### Procedure:

500 grams of HMT containing 12.25% RDX are placed in a 1500 cc beaker, 500 cc of acetone is added and the slurry is agitated for several minutes at room temperature. Before complete settling, the RDX-HNX-acctono solution is decanted.

To the residual HMX-RDX, another 500 cc of acctone is added. The slurry is heated on the steambath and while builing, agitated for several minutes. The builing RDX-HMX-acctone solution is decented. The residual HMY is now washed with cold acctone into a funnel. This HMX is now taken up in 95% alcohol, filtered and dried. Yield 353.9 gm or 70.78%.

All the acctume extracts are combined and evaporated to drynsss. Yield 137.5 gm or 26.5%.

3 -

#### Yield Balance:

Pure HMX obtained - 353.9 gm	70.78%
Total RDX-HMX mixture recovered - 137.5 gm	26.50%
Samples taken during process - 2.4 gm Loss during process	0.48% 2.24%
Total	100.00%

Various samples were analyzed for RXD content:

1. Crude HMCK	12.25% RDX
2. After first acetone washing	6.05 RD7
3. After second acetone washing	2.0% RL(
4. After third acetone washing	0.0% PTR
RDX-HMX sample recovered	54.5% RDX

Proparation of line Particle-size HMX by the Aspirctor Method:

Lissch-e 1100 gm HMX in  $4400~{\rm cc}$  of dimethyl sulfaxide. Filter the HMX solution.

- 2.
- Connect a clean aspirator to the water line. 3. 4.
- 5.
- 5.
- Convect a clean aspirator to the water line. Place a 55 gallon clean drum under the aspirator. Fasten a polyethylene tubing, long enough to reach easily to the bottom of the HMK-dimethyl sulformide contriner, to the side intake of the aspirator. Fasten to the bottom of the aspirator another polyethylene tube long enough to reach to the bottom of the 55 gallon drum. Open the water faucet and then place the polyethylene tube in the HMK container. Unite milty fine HMK separates out in the drum. Total duration of run is approximately 7 identical. 7. 8.
- 7 viautes. After all the HMX solution is sucked out of the container, the fater is turned off. The material is filtered and water washed. 9. 10.
- 11. If dry HMC is required, the material ( n be alcohol and ether washed.

#### A more efficient method to recover the RDX-HMX mixture:

- 1. Filter the combined hot acetone extracts.
- Pour while agitating the filtered extracts into at least 4 times its volume of water.
   Filter and dry, etc.
- 176

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Corro	<u>n</u>		
Ŵ	hite		
Stor			
	Nethod	iany -	
	Hazard Class (Quant' ty-Distance)	CLASS 9	× ×
	Compatibility Group	Group 1 (dry) Group M (wet)	
	Endation	None	
Refe	rences: 37		
(i Chess	) O. E. Sheffield, E. J. Murrey, A. Ital Research Laboratory Report No. 52	L. Rosen and B. W. Kanouse, <u>Prop</u> -TK1-23, 7 April 1952.	erties of HMX, PA
(1	b) W. E. Buckmann, The Preparation of	HOX, OSRD Report No. 1981, 3 No	vember 1943.
(4 1 <b>9</b> 45	c) S. Livingston, C <u>haracteristics of</u>	Explosives HOX and DPHENE, PAIR N	0. 1561, 6 September

(d) R. J. Finkelstein and G. Gemow, <u>Theory of the Detonation Process</u>, MAVORD Report No. 90-46, 20 April 1947.

(e) O. H. Johnson, HOK as a Military Replosive, MAVORD Report No. 4371, 1 October 1956.

(f) Also see the following Picatinny Arsenal Technical Reports on BMK:

<u>1</u>	ā	<u>6</u>	I	2
1741	2183	2016	1737	1709 2059

(g) C. Lenchitz, W. Bouch and R. Valicky, Enthalpy Changes, Heat of Fusion and Specific Heat of Basic Explosives, PATR No. 2504, January 1959.

37See footnote 1, page 10.

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HTA-3

		and the second	
Composition:		Malacular Weight:	91
HINCK 49	1	Oxygen Susance:	•
TNT 29		CO: %	-51
Aluminum 22		Density: gm/cc Cast	1.90
		Kalting Pulat: *C	
C/H Rotio		Freesing Point: "C	
impact Sensitivity, 2 Kg Wt:	·····	Seiline Paint: *C	
Bureau of Mires Apparatus, cm Sample Wt 20 mg		Remotive Inian, ng	
Picatinny Arsenal Apparatus, in. 17		_	
Sample Wt, mg 25		n <sup>2</sup>	
		n <u>o</u>	
Friction Pondulum Test:	1	Vocutia Stability Test:	
	affected	cc/00 Hrs, ot	
Fiber Shoe Un	affected	90°C	
Lifts Sullat Impact Test: 10Trials , %		- '00°C	
	8" A1	120°C	0.37
	50	135°C	•
Partials -		150°C	
Burned 10		200 Grom Bomb Sand Test:	
Unaffected 0	50	Sand, pm	61.3
Explosion Temperature:	°c	Sensitivity to Initiation:	
		Minin um Detonating Charge, gm	
1		Marcury Fulminate	
5 Flames erratically	370	Lead Azide	0.30
10		Tetryl	
35 20		Bailistic Morter, % TNT:	120
		- Treast Test, % TNT:	
'S'C International Heat Test: % Loss in 48 Hrs		Plate Dent Test:	
		Method	
60°C Heat Test		Condition	
% Loss, 1st 48 Hrs		Confined	
% Loss, 2nd 48 Hrs		Density, gm/cc	
Explosion in 100 Hrs		Brisance, % TNT	
Rieman Million In Anna		- Derenation Rate:	
flemmebility Index:		Confinement	None
tygrescopicity: %		- Condition	Cast
-yy		Charge Diameter, in.	1.0
/eletility:		Density, gm/cc	1.90
· ····································		Rate, meters/second	7866

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N. W. Carlos

HTDA-3

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Bourter Sanattivity Test:		Decomposition Equation:	
Condition		Oxygen, atoms/sec	
Tetryi, gm		(Z/sac)	
		Heat, kilocalorie/mole	
Wax, in. for 50% Detonation		(たH, kesi/mol)	
Wax, gm		Temperature Range, *C	
Density, gm/cc		Phase	
		<u>l</u>	
Heat of:			
Combustion, col/gm	3687	Armor Plate Impact Test:	
Explasion, col/gm	1190		
	680	60 mm Morter Projectils: 50% Inert, Velocity, ft/suc	
· · · · •			
Formation, col/gm		Aluminum Fineness	
Fusion, cal/gm			
		500-16 General Purpose Sombo:	
Specific Heat: cal/gm/°C			
32 <sup>2</sup> to 74°C	0.245	Plate Thickness, inches	
		1	
		13/4	
		1142	
		134	
Burning Rote:			
Cm/36C			
		Bomb Drop Test:	
Thermal Lunductivity:			
col/sec/cm/°C		17, 2000-lb Semi-Armer-Piercing I	iemb vs Concrete:
Coefficient of Expansion		Max Safe Drop, ft	
Linear, %/°C		500-lb General Purpete Bersh vs (	
		200-m Official Labora parts as (	, and that a
Volume, %/°C		Height, ft	
Herdness, Moh. Scaln:		Trials	
		Unoffected	
Young's Modulton:		Low Order	
		High Order	
E', dynes/cm*			
E, Ib/inch <sup>2</sup>		1000-lb General Purpose Bomb vs (	Cemento:
Density, gm/cc			
		Height, ft	
Compressive Strength: Ib/inch*	2260	Trials	
	See below	Unaffected	
Vapor Proseuro:		Low Order	
C mm Mercury 2		High Order	
Compressive Strength: 1b/inch	*		
Average (10 tests) High	2360 25 <b>3</b> 0	Ultimate Deformation: %	_
Low	1910	Average (10 tests)	2.81
	2/10	High Low	3.22 2.52
· · · · · · · · · · · · · · · · · · ·		1	5, JE

Test specimen 1/2" x 1/2" cylinder (approximately 3 gm) pressed at 3 tons (6,000 lb) total load or 30,000 psi with a 2 minute time of dwel'.

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State Southern

EDA-3

Fregmentation Test:	Shaped Charge Effectiveness, TNT == 108:	
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth	
Total No. of Fragments: For 1 NT For Subject HE	Color:	Gray
3 inch HE, W42A1 Projectila, Let KC-5: Density, gm/cc Charge Wt, Ib	Principal Uses: HE projectile and bomb	filler
Total No. of Fregments: For TNT	Nuthed of Looding:	Cast
For Subject HE	Looding Density: gm/c2	1.90
Fregment Velocity: ft/ser At 9 ft At 25½ ft Density, gm/cc	Storege: Method	Lary
Blast (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 9
Ain: Pook Pressure Impulse Energy	Compatibility Group Exudation	Group I None
Air, Confined: Impulse	Work to Produce Rup 198. St-lb/inch <sup>3</sup> Average (15 tests) 2.7 High 3.3 Lov 2.4	7 9
Peak Prissure Impulse Energy	Sfflux Viscomit; Smybolt Seconds:	24.8
Underground: Peak Pressure Impulse Energy		
	"Test specimen 1/2" x 1/2" cylinder mately 3 gm) pressed at 3 tons (6,0 total load or 30,000 psi with a 2 m time of dwell.	00 1ь)

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HT.-3

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#### Modulus of Elasticity: \*

	lt/inch <sup>2</sup>
Average	89,200
High	97,400
Low	76,300

\* Test specimen 1/2" x 1/2" cylinder (approximately 3 gm) pressed at 3 tons (6,000 lb) total load or 30,000 psi with a 2 minute time of dwell.

#### Setback Sensitivity Test: (a)

Critical Pressure	119,000 psi *
Density, gm/cc	1.92

\* Pressure below which no initiation is obtained and above which an increasing percentage of initiations can be expected as the setback pressure increases.

#### Preparation:

Procedure similar to that used for Torpex.

# References; 38

(a) 1st Indorsement from Chief, Explosives Development Section, to Chief, Explosives Research Section, Picatimny Arsenal, dated 12 May 1953. Subject: "Properties of Octols and HDA-3."

(b) R. Brown and R. Velicky, <u>Heat Capacity of HTA-3</u>, Picatinny Arsenal General Laboratory Suport No. 58-HI-509, 5 May 1958.

<sup>38</sup>See footnote 1, page 10.

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Lead Azide

Composition: %	Molecular Weight: (PbN <sub>6</sub> ) 291	,
N 28.8 N N N N N N N N N N N N N N N N N N N	0x, yen Selence: C J. % -5.5 C(1 % -5.7	
Pb 71.2	Density: gm/cc Crystal 4.80 Destripated 4.38	_
	Melting I. Vat: "C Decomposes	-1
C/H Ratio	Freezing Point: "C	-
Impact Sensitivity, 2 Kg Wt: Pure Dextrinated	Boiling Point: *C	
Bureau of Mines Apparatus, cm 10 17 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 3 5 Sample Wt, mg 30 28	Refrective Index. ng ng ng	
Friction Pendulum: Test:		
Steel Shoe Explodes	CC/40 Hrs, at 90°C	
Rifle Bullet Impact Test: Trials	- 100°C 1.0	
%	120°C 0.07	
Explosions Partials	157*C	
Burry.d	200 Grum Bomb Sand Test:	
Viofiected	Sond gm Black powder fuse 19.	į
Englecion Yemperature: *C Seconds, 0.1 (no cap used) 390	Scasitivity to Initiation: Minimum Detonating Charge, gm	
l 35ර 5 Exploses 240	Mercury Fulminate	
5 Explores 340 10 335	Lead Azide	
15 335	Tetryi	_
<b>20</b> 335	Bellistic Morter, % TNT:	
75°C International Heat Test:	Treuzi Test, % TNT: (a) 39	
% Loss in 48 H-s	Plate Dent Test: Method	
100°C Hast Test:	Condition	
% Loss, 1st 48 Hrs 0.34	Confined	
% Loss, 2nd 48 Hrs 0.05	Density, gm/cc Britance & TNIT	
Explosion in 100 Hrs None	Brisance, % TNT	
Flommebility Index:	Detension Rote: Pure Lead Azide Confinement	
Hyprescepicity: % Dextrinated Not Dextrinated 0.8 0.03	Condition Pressed Charge Diameter, in.	
Veletility:	Density, gm/cc 2.0 3.0 4.0	
-	Rate, meters/second 4070 4630 5180	1

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Lead	Azid	e
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### AMCP 706-177

Fragmentation Test:	Shaped Charge Effectiveness. TN	T = 100:
90 mm HE, M71 Projectile, Let WC-91:	Glass Coner	utile Cones
Density, gm/cc	Hole Volume	
Charge Wt, Ib	Hole Depth	
Total No. of Fragments:	Celer:	
For TNT	Court (197	White-buff
For Subject HE	Principal Uses: Detonators, 1	
3 inch itl, M42A1 Projectile, Let KC-5:	and compercis	al blasting caps
Density, gm/cc		с. С
Charge Wt, Ib		
Tatul No. of Fragmonts:		
For TNT	Mathed of Londing:	Pressed
For Subject HE		
	meeting semany: Gui/cc -	x 10 <sup>3</sup>
Fregment Velocity: ft/sec	2.62 2.71 2.96	15 3.07
At 9 ft At 25½ ft	Str ye:	3.01
Density, gm/cc		
	Method	Wet
Siest (Relative to TNT):	Hazard Class (Quantity-Diston	ce) Class 9
Air:	Compatibility Group	Group M (wet)
Peak Pressure		
. mpulse	Exudation	None
Energy	·····	
Air, Crafiaed:	Compatibility with Metals:	-
Impulse	Dry lead aride does not	
	rode steel, irou, nickel, zinc, copper, tin or culmi	aluminum, lead,
Under Water:	affect coatings of acid-pr	oof tlack paint.
Peak Pressure	oil, NRC compound or shell	ac. Lead azide in
Impulsa Enorm	the presence of moisture of copper; and with copper, i	
Energy	ly scritive and dangerous	copper azide.
Underground:	Specific Heat; cal/gm/°C	
Pack Pressure	°c	
Impulse	-50	0.110
Energy	0	0.110
Heat of:	25 50	0.110 0.110
Combustion, cal/gm 630 Explosion, cal/gm 367		V. 110
Explosion, cal/gm 367 Gas Volume, cc/gm 308	Thermal Conductivity:	1
Formation, cal/gm -346	cal/sec/cm/°C (Pure)	1.55 x 10 <sup>-4</sup>

# AMCP 706-177

#### Lead Aside

### Compatibility with Metals:

Dry: Steel, iron, nickel, aluminum, lead, zinc, copper, tin, stainless steel, brass and bronse were unaffected by aix years' contact with dry lead azide at ambient terresture and 50°C. Momel, chroms-nickel and Incomel were unaffected under the same conditions in two and one-balf years.

Net: Copper and sinc are rapidly attacked by moist lead azide, while aluminum is not attacked in 2% hours. Monel, chrome-nickel and incomel are not attacked by lead azide ( $\frac{1}{2}$ ) moisture) after 29 wonths' exposure at ambient temperature and 50°C, and J-1 magnesium-aluminum alloy is very slightly corroded.

Lond Aside

Sample Tested	Lead Aride	D	Azide lus Water	Lead A plu 205 Ma	8	Lead Aside plue 305 Ethyl Alco- bol (955)
Friction Pendulum Tea	t:					
(All IA destrinated)						
Shoe	Fiber	Fiber	Steel	Fiber	Steel	Piber
Ho. of Trials Explosions Greatings Unaffected	1 1 0	10 0 10	12 0 10	0 0 10	1 2 1	1 1 0 0
Impact Sensitivity, 2	E Kg Ht:					
(All IA destrinated)	•••					
PA Apparatus, incl	nes 4	9	,		9	4
Activation Energy: (	=)					
Koel/mole Induction Period,	seconds	23.7 <sup>1</sup> 0.5-10				
Initiating Efficien	, Grams Requ	uired to Gi	ve Comple	te Initia	tions of:	
		Destring	ted Aziae	<u>(em)</u>		
1977 Tetryl ROX PETR			0.25 0.10 0.05 0.02			
Bensitivity to Stati	c Discharge,	Joules (P	are Lead A	zide) (b)		0.0070

Sensitivity to Static Discharge, Joules (Pure Lead Azide) (b)

Lead Azide

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# Compatibility of Dextrinated Lead Azide with Black Powder: 100°C Vacuum Stability Test, cc/40 hr:

Sample Wt (gra)	Material	<u>cc</u>
1.0	Lead Azide	0.50
1.0	Black Powder	0.38
2.0	50/50, Lead Azide/Black Powder	1.26
olubility of Pure Lead Azide;	gm/100 gm of Water:	

<u>So:</u> 0

<u>~c</u>			2
20			0.05

Preparation of Lead Azide (Dextrinated): (du Pont procedure)

Lead nitrate solution: This is prepared by dissolving 164 lbs lead nitrate and 8.25 lb. destrine in defonized water, the solution allowed to settle, and sodium hydroxide added to bring the solution to a pH of 5.4. The final concentration of the solution is then adjusted to 7.4% lead nitrate, 0.375% destrine by addition of defonized water.

The lead axios is precipitated at a solution temperature of  $160^{\circ}$ F, using 60 parts lead nitrate and 50 parts sodium sxide solution. The latter is added to the former in 23 minutes, under agitation (no baffles are used in the precipitation vessel), the mixture cooled to room temperaturs in 12 minutes, and shlowed to settle 10 minutes. The mether liquor is decented and the remaining shurry washed before packing.

#### Origin:

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First prepared in 1891 by T. Curtius (Ber 24, 3345-6) by adding lead acetate to a solution of sodium or annonium azide. F. Hyronimus (French Patent 384,792) should be credited with the first attempt in 1907 to use lead azide with some success in the explosive industry. Its com-mercial manifacture started in Burrye before World War II and in the United States since 1931 as military or commercial grade "destrinated" lead azide.

#### Destruction by Chemical Decomposition:

#### Lond axide can be decomposed by

(1) mixing with at least five times its weight of a 10% solution of sodium hydroxide and allowing the mixture to stand for 16 hours. Decant the supermatant solution of sodium azide and drain into the soil.

(2) dissolving in a 10% solution of ammonium accute and adding a 10% solution of sodium or potassium bichromate until no more lead chromate is precipitated.

(3) wetting with 500 times its weight of water, slowly adding 12 times its weight of 25% sodium mitrite, stirring, and then adding 14 times its weight of 36% mitric or glacial acetic acid. A red color produced by the addition of ferric chloride solution indicates Lead Azide is still present.

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### AECP 706-177

### Lead Azide

(4) dissolving in 50 times its weight of 15% ceric ammonium nitrate. The azide is decomposed with the evolution of nitrogen.

### References: 39

(a) Ph. Naoua, <u>2 ges Schiess Sprengatoffv</u>, 181, 229, 267 (27 June 1932).

(b) F. W. Brown, D. H. Kusler and F. C. Gibson, <u>Sensitivity of Explocives to Initiation</u> by Electrostatic Discharges, U. S. Dept of Int, Burcau of Mines, RI 3852, 1946.

#### (c) C. Lenchitz, Ice Calorimeter Determination of Enthalpy and Specific Heat of Eleven Organometallic Compounds, PATR #2224, November 1/55.

(d) Also see the following Picatinuy Arsenal Technical Reports on Lead Azide:

<u>o</u>	1	2	3	<u>4</u>	٤	<u>6</u>	I	<u>8</u>	2
550 580 600 760 1450	561 861 1451 1651	832 852 932 1132 1152 1352 1372	393 1393 1493 2093 2133	534 784 944 2164 2204	255 525 1325 1485	326 856 1316 1486 1556	567 637 657 707 1737 2227	628 708 748 788 836 1388 1528 1538 1538	609 715 749 769 849 999 2179

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39See footnote 1, page 10.

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Lead 2,4-Dinitroresorcinate (LDNR)

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Composition:	Molecule: Weight: (PbC6H2N2O6) 405
c 17.8 [ 0]	Oxygen Belence:
	CO% -32 CO % -8
	+ 0
0 23.7 Pb 51.1	Density: gm/cc Crystal 3.2
	Molting Point: "C
C/H Ratio 0.549	Freezing Point: *C
Impact Sanshivity, 2 %g Wt: Bureau of Mines Apparatus, cm 1 kg wt 30	Boiling Point: "C
Somple Wt 20 mg	Refractive Index, no
Picatinny Arsenal Apparatus, in.	n <sub>an</sub>
Sample Wt, mg 20	nm
Friction Pandulum Test:	
Steel Shoe	Vecuum Stability Test: cc/40 Hrs, at
Fiber Shoe	90°C
Rifle Bullet Impact Test: Trials	120°C (73 minutes) Explodes
Sum los inte	135°C
Explosions	150°C
Partials Burned	
Burned Unoffected	200 Grem Bomb Send Test:
	Sond om Black powder fuse 20
Explosion Temperature: °C	Sansitivity to Initiation:
Seconds, 0.1 (no cop used)	Minimum Detonating Charge, gm
) 5. Pumladar - 265	Mercury Fulminate
5 Explodes 265	Leod Azide
10	Tetryl
13	Bellistic Morter, % TNT:
20	Treuzi Test, % TNT:
75°C Internetic al Heat Teet:	Plate Dans
% Loss in 48 Hrs	Metho
109°C Heat Test:	Condition
% Loss, 1st 48 Hrs 0.20	Confined
% Loss, 2nd 48 Hrs 0.02	Density, gnr/cc
Explasion in 100 Hrs None	Brisance, % TNT
Flammability Index:	Detenation Rate: Confinement
	Condition
Mygrescepicity: % 30°C, 90% RH 0.73	Charge Diameter, in.
	Density, gm/cc
Veletility:	

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### Lead 2,4-Dipitroresorcinate (LDNR)

Fregmentation Test:	Shaped Charge Effectiveness, TNT =	109:
90 mm HE, M71 Projectile, Let WC-91; Density, gm/cc Charge Wt, ib	Glass Cones Steel Hole Volume Hole Depth	Cones
Total No. of Fragments: For TNT	Color: Red	or yellow
For Subject HE	Principel Uses: Electric	detonators
3 inch HE, M42A1 Projectile, Let KC-S: Density, gm/cc Charge Wt, Ib		
Tatel No. of Progmants: For TNT	Mothod of Looding:	Pressed
For Subject HE	Looding Density: gm/cc	
Fregment Velo. 4y: ft/sec At 9 ft At 25½ ft	Storage:	
Density, gua/cc	Method	Wet
Blast (Relative to TNT):	Hozard Class (Quantity-Distance)	Class 9
Air: Peak Pressure Impulse Energy	Compatibility Group Exudation	None
Air, Confined: Impulse	Initiating Efficiency: 0.4 gm initiate tetryl pressed at 1	LDNR does not 1000 psi-
Under Weter: Peck Pressure	Heat of: Explosion, cal/gm	270
Impulse Energy		
Underground: Peak Pressure		
impulse Energy		

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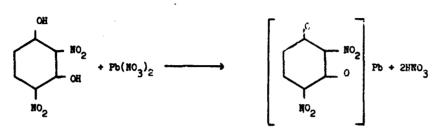
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### Load 2,4-Dinitroresorcinate (LDNR)

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Preparation:



To a solution of 5 grams of purified dimitroresorcin and 2.65 grams of anhydrous sodium to the in 500 cc of boiling water is added slowly a solution of 10 grams of lead mitrate ussolved in 60 cc of boiling water. The reaction mixture is constantly stirred during the indition of the lead salt and for about an hour afterward while the solution is allowed to cool to room temperature. The precipitate is filtered and washed thoroughly first with water and then with alcohol are other. It is dried in a steam oven.

#### Origin:

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2.4-dimitroresorcin was described in the 1881 edition of Beilstein (Beil VII, 885). The same compound was described in more detail by Weselsky, Benedikt and Bibl in 1882 (M II, 323). The land salt of 2.4-dimitroresorcinol appears to have been prepared between World War I and World War II by treating resorcinol with mitrous acid and oxidizing the resulting dimitrosoresorcinol to dimitroresorcinol. Lead mitrate solution was then added to a solution of the 2.4-dimitroresorcinol to which sodium carbonste had been added to form the soluble sodium salt (J. D. Fopper, PATR No. 480, March 1954). The LINE exists in two forms differing in physical characteristics but possessing similar explosive properties. These forms are red and orange in color (K. S. Warren, PATR 1448, September 1944).

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(a) See the following Picatinny Arsenal Technical Reports on Lead 2,4-Dinitroresorcinate:

<u>o</u>	3	<u>4</u>	<u>8</u>	2
480 580	453	1004	1328 1448	859 1079

40See footnote 1, page 10.

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### Lead 4,6-Dinitroresorcinol Basic (LDNR Basic)

Composition:	Melocular Weight: (Pb2C6R4N208) 646
$\begin{array}{c} % & 0 - Fb - 0H \\ C & 11.2 \\ H & 0.6 \\ N & 4.3 & 0_2 N \end{array}$	Скуден Belence: СО, % -20 СО % - 5
0 19.8 Pb 64.1 0 - Pb - OH	Density: gm/cc
$\uparrow$	Melting Point: *C 213
NO <sub>2</sub> C/H Ratio 0.177	Freezing Point: "C
Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 1 kg vt 60	Boiling Peint: "C
Sample Wt 20 mg Picar:nny Arsenal Apparatus, in. Sample Wt, mg 20	Refrective Index, nº nº nº
Fristics Postuluum Test:	Vocuum Stubility Test:
Steel Shoe	cc/40 Hrs, at 90*C
Rifle Bullet impoct Test: Trials	
% Explosions	135°C
Portials	150°C
Burned Unaffected	200 Grom Bomb Sond Test: Mathe Bowder fuse 15
Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 5 Explodes 295 10 15	Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryl
20	Ballistic Mortur, % 'SNT:
	Trenzi Test, % TNT:
75°C International Heat Test: % Loss in 48 Hrs	Plate Dant Test: Methori
100°C Host Test:	Condition
% Loss, 1st 48 Hrs 0.14	Confined
% Loss, 2nd 48 Hrs 0.0	Density, gm/cc Brisance, % TNT
Explosion in 100 Hrs None	
Flemmeblility Index:	Detensition Rate:     Cunfinement
Hygrescopicity: %	Condition Charge Diameter, in:
Veletility:	Density, gm/cc     Rate, meters/sucond

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### Lead 4,6-Dinitroresorcinol Basic (LINR Basic)

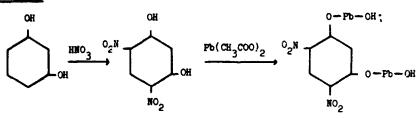
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Frequentities Test:	Sheped Charge Effectiveness, TNT ==	100:
90 mm HE, M71 Projectile, Let WC-91:	Gloss Cones Stee	l Cones
Density, gm/cc	Hole Volume	
Charge Wt, Ib	Hole Depth	
Total No. of Fragments:	Color: Re	d or yellow
For TNT		
For Subject HE	Principal Uses: Elect	ric detonators
3 inch HE, M42A1 Projectile, Let KC-5:		
Density, gm/cc		
Charge Wt, Ib		
Total No. of Fragments: For TNT	Mathed of Loading:	Pressed
For Subject HE	Loading Dentity: gm/cc	
Fregment Velocity: ft/sec At 9 ft At 25½ ft	Sterope:	<u> </u>
Density, gm/cc	Method	11-1
	memod	Wet
liest (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 9
Aim	Compatibility Group	
Peak Pressure		
Impulse	Exudation	Kone
Energy		
Air, Confined:	Initiating Efficiency: 0.4 gr	
Impulse	does not initiate tetryl pr psi.	ressed at 3000
Under Water: Peok Pressure		
Impulse		
Energy		
Underground: Pack Pressure		
Impulse		
Energy		

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ad 4,6-Dinitroresorcinol Basic (LDNR Basic)





(a) One hundred grams of pure resorcin is fused in a porcelain casserole and immediately poured on a glass plate. After cooling, the cake is ground in c mortar to pass a U. S. Standard Ho. 6 mesh screen. Four hundred grams of 98 percent nitric acid in a one pint capacity Devar jar is stirred mechanically while carbon dioxide snow is added in small pieces. When the temperature falls to -20°C, 40 grams of the granulated resorcin is added in small pieces. When the temperature falls to -20°C, 40 grams of the granulated resorcin is added in small quantities. Simultaneous addition of solid carbon dioxide as required prevents a rise of temperature of more than 5 degrees throughout the entire experiment. Five minutes after the last portion of resorcin is introduced, the mixture is further cooled to minus 50°C, and finally drowned with vigorous stirring in fi/e times its volume of cracked ice, in water. This mixture is allowed to stand for one hour and the product then filtered, washed, and partially dried, weight  $\frac{1}{4}3.6$  grams. The crude  $\frac{1}{4}, 6$ -DRR is purified by first dissolving the product in an aquecus 5 percent sodium hydroxide solution (17.4 grams of sodium hydroxide in  $\frac{3}{4}0$  cc of water). The resulting solution is then neutralized by gradually adding it to a boiling solution of 21.4 grams of 96 percent sulphuric acid in 150 cc of water. The resulting precipitate of  $\frac{1}{4}, 6$ -DRR is filtered hot on a suction filter and air-dried. Yield, 27.5 grams (37.8 percent of the theoretical).

(b) Five hundredths (0.05) mole (18.96 grams) of lead acctate is dissolved in 67 cc of warm water, into which is gradually stirred 0.10 mole (4.0 grams) of sodium hydroxide dissolved in 67 cc of water. Stirring is continued for five minutes. After settling, the white lead hydroxide is washed by decantation three times with 100 cc portions of distilled water, and used immediately for the next operation.

(c) A 0.0278 mole (5.56 grams) quantity of the 4,6-DNR prepared under (a) above, is dispersed in 270 cc of valuer by vigorously beating with a motor stirrer. After heating this dispersion to  $90^{\circ}$ C, the 0.05 mole of lead hydroxide prepared above in slurry form is introduced in small portions. Agitation is continued for three hours at  $90^{\circ}$ C. The basic lead 4,6-DNR is washed cuce by decantation, and again on the filter with slochol. After drying overnight in a desiccator charged with calcium chloride, the product weighs 15.6 grams.

#### Origin:

Both the 2,4- and 4,6-dinitroresorcin were d scribed in some detail by Weselsky, Benedikt and Hubl in 1882 (M II, 323). Typke prepared the 4,6-dinitroresorcin in 1883 by hydrolyzing the nitration product of resorcin diacetate (Ber 16, 551). A 'sore direct and economical method of preparation suitable for production scale manufacture was developed during World War II by the British (Ministry of Supply Pouch Item W-154-21s, "M nufacture of 4,6-Dinitroresorcin and Lead 4,6-Dinitroresorcinate"). This procedure consisted of preparing 4,6dinitroresorcinol by direct nitration of granulated resorcin and allowing the product in slurry to react with an excess of lead hydroxide at 90°C. This basic salt can be prepared in two forms: (1) a micro-crystalline, yellow, low-density form and (2) a denser, brick-red form. Both products have the same chemical composition and the same sensitivity to impact (PATE 1448, September 1944).

Semperation:	Melecular Weight: (PbC6H3N309	) 468
C 15.4 H 0.6 N 9.0 $O_2 N + NO_2$ PbH_0	Oxygen Belcace: CO <sub>2</sub> % CO %	-19 2
0 30.8 Po 44.2	Density: gm/cc Crystal	3.02
NO <sub>2</sub>	Melting Point: 'C Explodes	260-310
C/H Ratio 0.320 L-	Freezing Point: "C	
Impact Sansitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 17	Boiling Point: *C	
Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 3; (8 oz wt) 8 Sample Wt, mg 22	Refractive Index, ng ng ng	
Friction Pendulum Test:	Vocuum Stobility Tert:	
Steel Shoe Detonates	cc/40 Hrs, at	
Fiber Shoe Detonates	90°C	0.4
Rific Bullet Impact Test: Trials	320°C	0.3
Suplavia.	135°C	·· ·
Explosions Partials	150°C	
Burned	200 Grem Bomb Sand Test:	
Unoffected		24
Explosion Temperature: 'C	Sond gm Black powder fuse	11_1
Seconds, 0.1 (no cap used)	Sensitivity to Initiation: Minimum Detonating Charge, g	m
1	Mercury Fulminate	Trace#
5 Emplodes 282	Lead Azide	Trace*
10 276	* <.001 gm, alternative	
15 272 20 267	Bellistic Morter, % TNT:	
2C 267	Trousi Test, % TNT: (a)	40
75°C International Host Text: % Loss in 48 Hrs	Plote Dent Test: Method	
100°C Heat Test:	Condition	
% Loss, 1st 48 Hrs 0.38	Confined	
% Loss, 2nd 48 Hr.; 0.73	Density, gm/cs	
Explosion in 100 Hrs None	Brisance, % TNT	
	Detenction Rate: Confinement	
Flommability index:		
Flemmebility index: Hygruscepicity: % 25°C, 100% RH 0.05	Condition Chorae Diameter	
	Condition Charge Diumeter Density, gm/cc	2.9

Lead Styphnate

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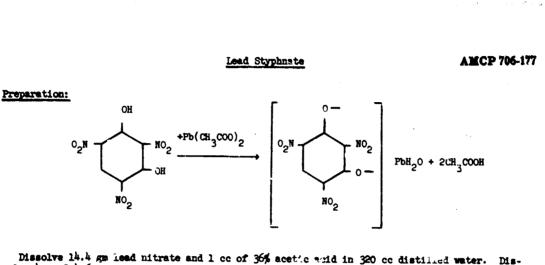
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### Lead Styphnate

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Fregmentation Test:	Shoped Charge Effectiveness, TNT ==	100:
99 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Hole Volume Hole Depth	Cones
Total No. of Fregmants: For TNT	Color: Orange-reddish b	rown
For Subject HE <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	Principal Uses: Igniting charge, of priming compo	
Totol No. of Fragments: For TNT For Subject HE	Muthod of Looding:	Pressed
	Looding Density: gm/cc	
Program Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc	Storogo: Method	Wet
Siget (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 9
Air: Peak Pressure Impulse Energy	Compatibility Group Exudation	Group M (wet) None
Air, Confined: Impulse Under Water:	Activation Energy: kcal/mol Induction Period, sec	75• <b>3</b> 9 0.5-10
Peak Pressure Impuls	<u>Specific Heat: cal/cm/°C</u>	(c)
Energy Underground: Peak Pressure Impulse	-50 -50 -25 -50	0.141 0.158 0.164 9.167
Energy Heat of:		<b>9.1</b> 9,
Combustion, cal/gm 1251 Explosion, cal/gm 457 Gas Volume, cc/gm 368 Formation, cal/gm -92		



Dissolve 14.4 gm lead nitrate and 1 cc of 36% acetic wid in 320 cc distilled water. Dissolve 4 gm 2,4,6-trinitroresorcinol and 1.73 gm sodium cervonate in 80 cc distilled water. Add the 1.44 acetate solution to the trinitroresorcinol solution, under agitation, keeping the temperature at  $70^{\circ}$ - $75^{\circ}$ C and continue stirring for 3 hours at this temperature. Cool to  $20^{\circ}$ C in 5 hours. Evaporate the solution to 1/3 its volume, cool, filter and wash the product well with water (to neutrality).

Sensitivity to Static Discharge, joules: (b)	0.0009
Loss in Weight at 105°C: 5	
3 hours 6 hours 9 hours	0.02 0.23 0.23
Effect of Storage for 2 Months at 30°C, on:	
Explosion Temperature Test Value Sand Test Value Sensitivity to Initiation	Nil Nil Nil
Solubility, gm/100 gm (\$) in:	
Glycol Diacetate	

°c	ž
20-25	0.1

Origin:

•

First described in 1914 by von Hurtz and found to be a relatively poor initiator by Wallbaum in comparison to other primary explosives. (Z ges Schiess Sprengstoffv 34, 126, 161, 197 (1939)) Moisak showed that lead styphnate could be used as an insulating (cover) material for lead azide providing protection from mechanical and chemical influences and, at the same time, increasing the detonating ability of the total charge (Transactions of Butlerov Inst Chem Tech Kasen (Russia) 2, 81-5 (1935).

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#### ead Styphnate

#### Destruction by Chemical Decomposition:

Lead styphnate is decomposed by dissolving it in at least 40 times its weight of 20% socium hydroxide or 100 times its weight of 20% ammonium acetate and adding a solution of sodium dichromate, equal to half the weight of styphnute and 10 parts of water.

### Peferences: 41

(a) Suport AC-9,56/Org Ex 74.

(b) F. W. Brown, D. H. Kurler and F. C. Gibson, <u>Sensitivity of Explosives to Initiation by</u> <u>Electrostatic Discharges</u>, U. S. Dept of Int, Bureau of Mines, RI 3852, 1946.

### (c) C. Lenchitz, <u>Ice Calorimeter Determination of Enthalpy and Specific Heat of Eleven</u>. <u>Organometallic Compounds</u>, PATR No. 2224, November 1955.

(d) Also see the following Picatinny Arsenal Technical Reports on Lead Styphnate:

<u>o</u> .	<u>1</u>	2	3	<u>4</u>	<u>6</u>	I	<u>8</u>	2
1450 2220	11	1352 2032	453 2093	2164	1316	407 1737 2077	318	2179

<sup>41</sup>See footnote 1, page 10,

e,

# Mannitol Hexanitrate (Nitromannite)

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Competition: CH20102	Melecular Weight: (C6H8N6018) 452
O_NOCH	Oxygen Belencr:
U 13+9 -	CO. % 7.1
н 1.6 огносн	CO % 28 3
N 18.6 HCONO2	Density: gm/cc 1.73
HCONO	Melting Poluc: "C 112-113
0 63.8 CH <sub>2</sub> ONO <sub>2</sub>	Freezing Pelet: "C.
C/ 1 KNR 0. (33	
Import Sensitivity, 3 Kg Wt: Bureau of Mines Apparatus, cm 11	Bailing Point: 'C Decomposes 150
Sample V/t 20 mg	Refrective Index, no.
Picatinny Arsenal Apparatus, in. 4	n
Sample Wt; mg 11	ns
Friction Pewdulum Yest:	Vocuum Stability Test:
Steel Shoe Detonates	cc/40 Hrs, at
Fiber Shos Unaffected	90°C
Lifie Bullet Impect Test: Trials	100*C
%	120°C
20 Explosions	135°C
Partials	150°C
Burned	200 Grem Pemb Send Test:
Unoffected	Sand, ;m 68+5
Explasion Temperature: °C	Sensitivity to Initiation:
Seconds, 0.1 (no cop used) 160-170 (a)	Minimum Detonating Charge, gm
1 2 <u>3</u> 2 (b)	Mercury Fulminate
5 175 (c)	Lead Azide 0.06
10	Tetryl
15	Sollistic Morter, % TNT:
20	Trougt Test, % TNT: (c) 172
75°C International Heat Test:	
% Loss in 48 Hrs 0.4	Plate Dont Test: Mathod
1081C March Tanh	Condition
100°C Hest Test:	Confined
% Loss, 1st 48 Hrs	Density, gm/cc
% Loss, 2nd 48 Hrs	Brisance, % TNT
Explosion in 100 Hrs (Frothed) 48 hours	
Flammability Index:	Detension Rote: (d)
	Confinement Yes Condition Pressed
Hyprescepicity: % 30°C, 90% RH 0.1.7	
The second s	Charge Diameter, in. 0-5
Velstility:	Density, gm/cc 1.73 Rote meters/second 8250
	Rate, meters/second 8250

Contraction of

# AMCP 706-177

### Mannitol Hexanitrate (Nitromannite)

Fregmentetion Test:	Shapid Charge Effectiveness, TNT = 100:		
90 mm HE, M71 Projectile, Let WC-91:	Tlass Cones Steel Cones		
Density, gm/cc	Hole Volume		
Charge Wt, ib	Hole Depth		
Trtal No. of Fragments:			
For TNT	Color:		
For Subject HE			
	Principal Uses: Secondary charge in detonators (ref i), and in blasting caps designed to		
3 inch HS, M42A1 Projectile, Let KC-5:	be initiated by a fuse (ref j)		
Density, gm/cc Charge Wt, Ib			
Charge Wr, ro			
Total No. of Freymonts:			
For TNT	Method of Looding: Pressed		
For Subject HE			
	Loading Density: gm/cc		
Fragment Velocity: ft/sec			
At 9 ft At 25¼ ft	Steroge:		
Density, gm/cc			
	Method Dry		
-Bleet (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9		
Air:	Compatibility Group		
Peak Pressure			
Impulse	Exudation None		
Energy			
Air, Confined:	65.5° ( K1 Test:		
Impulse	Minutes 6		
Under Water: Peak Pressure	Heat of: (e, f, g)		
Impulse			
Energy	Combustion, cal/gm 1515 1525 Explosio., cal/gm 1390 1454 1468 1520 Formation, cal/gm 337 345 366		
Underground: Peak Pressure			
impulse			
Energy			



# Mannitol Hexanitrate (Nitromannite)

#### Solubility:

a. Insoluble in water.

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- b. Slightly soluble in cold alcohol (2.9 gm at 13°C).
- c. Slightly soluble in ether (4 gm at 9°C).
- d. Very soluble in hot alcohol.

#### Preparation: (Laboratory Method) (k)

Cool to below 0°C, 50 gm of 98%-100% nitric acid placed in a 300 milliliter Erlenmeyer Pyrex flask provided with a thermometer and immersed in an ice-salt mixture.

b. Introduce in small portions, 10 gm of d-mannitol, while swirling the flask to break up any lumps of mannite which might form. Keep the temperature below 0°C.

c. After solution is complete, add 100 gm of concentrated sulfuric acid from a dropping funnel, swirling the flask in an ice-salt mixture to keep the temperature below  $0^{\circ}C$ .

d. Filter the resulting porridge-like slurry through a filter paper previously hardened by treatment with mixed acid.

e. Rinse the precipitate directly on the filter with water followed by dilute aqueous sodium carbonate and finally with water. (The resulting crude mannitol hexanitrate gives 15.2% N as intermined by the nitrometer.)

Dissolve the crude mannitol hexanitrate in boiling alcohol and filter through a waterheaded funnel.

Bring the filtraic to boiling and gradually add hot water until the appearance of the first turbidity.

h. Cool in an ice-salt bath, separate and dry the crystals. (Yield should be about 23 gm of material, melting at  $112^{\circ}-113^{\circ}C$  and having 18.58% N, the nitrogen being determined by the nitrometer. Theoretical yield would be 24.8 gm.)

#### Origin:

Mannitol hexanitrate was discovered in 1847 by Ascanio Sobrero who recommended it as a sub-stitute for mercury fulminate in percussion caps (Comp rend. 1847, 121). It is the hexanitric ester of d-mannitol which is widely distributed in nature, particularly in the plant Fraxinus ornus. N. Sokoloff, a Russian chemist, investigated the explosive properties of his and recom-mended in 1878 a method of preparation. Mannitol hexanitrate was thoroughly studied by Merthe-lot, Sarran and Vieille. Example, Menard, Strecker, Tichanovich (Ph. Naoum, <u>Nitroglycerin and</u> <u>Nitroglycerin Explosives</u>, Baltimore, 1928, pp. 156, 247-250), and particularly by J. H. Wigner (Ber 30, 796 (1903)). More recent data have been reviewed by Guastalla and Racciu ("Modern Explosives," Industria Chimica 8, 1093-1102 (1933)).

### References:42

(a) G. C. Hale, Abstract of Available Information on the Preparation and Explosive Proper-es of Hexanitromannite, PA Special Report No. 238, 30 July 1925. ties

42See footnote 1, page 1C.

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### AMCP 706-177 Mannitol Hemmitrate (Mitromannite)

(b) C. A. Taylor and W. H. Rinkenbach, "Sensitiveness of Detonsting Compounds to Frictional Impact, Impact, and Heat," J. Frank Inst 204, 369-76 (1927).

(c) Ph. Macum, Z ges Schiess - Sprengstoffv (Nunich), pp. 181, 229, 267 (27 June 1932).

(d) H. Kast, Z angew Chem, 36, 74 (1923).

(e) A. Schmidt, Z ges Schiess - Sprengstoffv 29, 262, (1934).

Landolt and Börnstein, E III, p. 2914.

(f) A. Marshall, <u>Explosives</u>, <u>Their Manufacture</u>, <u>Properties</u>, <u>Tests</u>, and <u>History</u>, Vol III, London (1932) p. 39. Ph. Maous, <u>Hitroglycerin and Hitroglycerin Explosives</u>, Baltimore, (1928), pp. 156, 247-250.

(g) A. Schmidt, Z ges Schiess - Sprengstoffv 29, 262 (1934) G. Fleury, L. Brissend and
 P. Ihoste, "Structure and Stability of Mitric Esters," Comp rend 224, 1016-18 (1947).
 W. R. Tomlinson, Jr., Fundamental Properties of High Explosives. Thermodynamic Relations for
 Use in the Estimation of Explosive Properties, PATR No. 1651, 22 April 1947.

(h) Sarran and Vielle, Men poudr 2, 161 (1884-1889).

(i) L. von Hurtz, U. S. Patent 1,878,652 (20 September 1932).

(j) L. A. Burrows, U. S. Patent 2,427,899 (23 September 1947).

(k) B. T. Fedoroff, Handbook of Explosive and Related Items, Picatinny Arsensl (unpublished).

(i) O. E. Sheffield, <u>Literature Survey on Munnitol Hezanitrate</u>, PA Chemical Research Laboratory Report No. 52-TMI-15, 23 January 1952.

(m) Also see the following Picatinny Arsenal Technical Roports on Mannitol Hemanitrate:

2	<u>4</u>	2	<u>6</u>	
1352	24 61	85	6	

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Mercury Fulminate

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Composition: 96	Molecular Weight: (HgC2N2O2) 285
с 8.4 о <u>— я — с</u>	Oxygen Belence:
N 9.8 Hg	CO: % -17 CO % .5.5
0 11.2 0 - N - C	Density: gm/cc Crystal 4.43
щ 70.6	Metring Point: "C Decomposes
C/H Rotio	Freezing Point: "C
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 5; (1 kg vt) 35	Boiling Point: "C
Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 2; (1 1b vt) 4 Sample Wt, mg 30	Refrective Index, no no no
Friction Pondulum Test:	Vecuum Stebliky Test:
Steel Shoe Explodes	cc/40 Hrs, at
Fiber Shoe Explodes	90°C
Rifle Bullet Impact Test: Trials	- 100°C Explodes
96	120°C
Explosions	135°C 150°C
Partials	150°C
Burned	200 Grem Bemb Sand Test:
Unaffected	Sond om Black powder fuse 23.4
Explosion Temperature: "C	Sensitivity to Initiation:
Seconds, 0.1 (no cop used) 263	Minimum Detonating Charge, gm
1 239 5 Explodes 210	Mercury Fulminate
10- 199	Leod Azide
15 194	Tetryl
20 190	Ballistic Mortar, % TNT:
	Treuzi Test, % TNT: (a) 51
75°C International Host Test: % Loss in 48 Hrs 0,18	Plate Dest Test: Method
100°C Hest Test: Exploded in 16 hours	Condition
% Loss, 1st 48 Hrs	Confined
% Loss, 2nd 48 Hrs	Density, gm/cc
Explosion in 100 Hrs	Brisonce, % TNT
	Detenction Roto:
	Confinement
Flemmebility index:	
-	Condition Pressed
Hygrescepicity: % 30°C, 90% RH 0.02	Condition Pressed Charge Diameter, In. Density, gm/cc 2.0 3.0 4.0

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## Mercury Fulminate

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Fregmentation Test:	Shaped Charge Effectiveness, TNT == 100:			
99 mm HE, M71 Projectile, Let WC-91; Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth			
Total No. of Fragments: For TNT	Color: White to gray			
For Subject HE 3 inch HE, M42A1 Projectile, Let KC-3: Density, gm/cc Charge Wt, Ib	Principal User: Detonators and ingredient of priming compositions			
Total No. of Fragmonts: For TNT For Subject HE	Method of Loading:         ps1 x 10 <sup>3</sup> 3         5         10         12         15         20           3.00         3.20         3.60         3.70         3.82         4.00			
Fragment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc	Looding Dansity: gm/cc Storage: Method Wet			
Blast (Rolative to TNT):	Hazard Closs (Quantity-Distance) Class 9			
Air: Peak Pressure Impulse Energy	Compatibility Group Group M (vet) Exudation None			
Air, Confined: Impulse	Stab Sensitivity:DensityFiring Point (inch-ounces)gm/cc0%50%100%3.913.24.35.5			
Under Weter: Peak Pressure Impulse Energy	$\begin{array}{cccccccccccccccccccccccccccccccccccc$			
Underground: Peak Pressure Impulse Energy	Activation Energy:         kcal/ani       29.81         Induction Period, sec       0.5-10         Heat of:       0         Combustion, cal/gm       938         Explosion, cal/gm       427         Cas Volume, cc/gm       243         Formation, cal/gm       -226         Specific Heat: cal/gm/°C       1.1         Thermal Conductivity:       1 x 10 <sup>-4</sup>			

 $\mathbf{c}^*$ 

### Mercury Fulminate

AMCP 706-177

10

Initiating Efficiency; Grams Required to Give Complete Initiation of:

Fulminate, gm	
0.25	
0.20	
0.19	
0.17	

Compatibility with Metals:

TNT Tetryl RDX PETM

Dry: Reacts rapidly with aluminum and magnesium. Reacts slowly with copper, zing, brass and bronze. Iron and steel are not affected.

<u>Wet:</u> Reacts immediately with aluminum and magnesium. Reacts rapidly with copper, zinc, brass and bronze. Iron and steel are not affected.

0.025

Sensitivity to Static Discharge, Joules: (b)

The Effect of Storage at 50°C (Dry) on the Purity of Mercury Fulminate

Months Storage	979 <sup>1</sup>	ecrystall: <u>980</u>	ized Lots <u>981</u>	<u>982</u>	Uncrystal) 505.6-7/31	Lized Lots 505.3-5/11
C L	99-75	99•77	<b>99•7</b> 9	99•79	<b>98.</b> 86	98.7
0 4 6 8 9 10	95 - <b>3</b> 8	<b>99</b> •45	99.54	99.47	95+95	98.7 97.4
9 10					94+95	94.9
12	98.74 98.26	<b>99.</b> 56	97.49	99.06 98.79	90.65	
13 14 15 16	98.22 97.52	99.30	99.30	98.19	83.76	
16 17	97.00 95.70	98.66	99.01	97.75 96.69	-	
17 18 23 26	94.81	98.58	98.45	97.90	79+99 74+52	
26					63.80	

#### Chemistry:

Mercuric fulminate readily decomposes in the presence of aqueous solutions, chlorides, carbonate and many other materials. Due to the presence of small amounts of mercury, formed by exposure to light or elevated temperatures, it readily forms amalgams with copper, brass and bronze, thus components containing these metals must be protectivel; coated if used with fulminate.

Solubility, Grams of Mercury Fulminate in 100 Grams of Water (\$):

°c	£
12	0.07
49	0.18

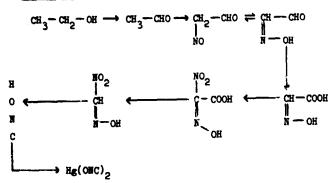
AMCP 706-177

### Mercury Fulminate

### Preparation:

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(Chemistry of Powder and Explosives, Davis)



Five gm mercury is dissolved in 25 cc of nitric acid (sp gr 1.42) without agitation, and this solution poured into 50 cc of 90% ethyl alcohol, resulting in a vigorous reaction, attended by evolution of white furmes and subsequent appearance of fulminate crystals. Red fumes then appear as precipitation of the product accelerates, and then white fumes again are evolved as the reaction moderates. After about 20 minutes the reaction is over; water is added, and the crystals are repeatedly washed, by decantation, with water to remove all acidity. The product is purified, rendered white, by solution in strong ammonium hydroxide, followed by reprecipitation with 30% acetic acid.

#### Origin:

Mercury fulminate was first prepared by John K. von Lovenstern (1630-1703) and in 1800 its preparation and properties were first described in detail by Edward Howard in a paper presented to the Royal Society of London (<u>Phil Trans</u>, 204 (1800). It was 1867 before the compound was used as an initiating agent, when Alfred Nobel invented the blasting cap and used mercury fulminate to detonate nitroglycerin (British Patent 1345 (1867)).

#### Destruction by Chemical Decomposition:

Mercury fulminate is decomposed by adding it, while stirring, to at least 10 times its weight of 20% sodium thiosulfate. Some poisonous cyanogen gas may be evolved.

#### References: 43

(a) Ph. Nacum - Z ges Schiess-Sprengstoffv (Munich), pp. 181, 229, 267 (27 June 1932).

(b) F. W. Brown, D. H. Kusler, and F. C. Gibson, <u>Sensitivity of Explosives to Initiation by</u> <u>Electrostatic Discharges</u>, U. S. Dept of Int, Bureau of Mines, RI 3852, 1946.

<sup>43</sup>See footnote 1, page 10.

(c)

T. Commerce

		ARCE (00-1)								
Also	see the	following	Picatinny	Arsenal	Techn	ical Rep	orts on	Mercury	Fulminate:	
<u>o</u>	<u>1</u>	2	3	<u>4</u>	2	<u>6</u>	I	<u>8</u>	2	
250 480 510 550 610 660 760 1220 1450	301 381 561 1651		23 203 393 433 833 1183 1393 2093		65 105 255 2855 415 4255 1365	266 366 556 865 986 1316 1486 1556 2146	277 297 407 537 567 637 857 1737	28 78 278 318 788 1836	199 609 749 849 999 1079 1389 2179	

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Composition :	Melecular Weight: (C.H.N.309) 255	_
<b>%</b> c 23.5 $O_2 NO - CH_2$ H 3.5 c m m	Oxyge         Belence:           CO	1
H 3.5 $O_2 NO - CH_2 - C - CH_3$ N 16.6	Density: gm/cc Liquid 1.47	
$0 56.4 0 2^{NO-CH_2}$	Molting Point: "C -3	
C/H Ratio 0.150	Freezing Point: "C	1 e 1
Impact Sensitivity, 2 Kg Wt:	Boiling Point: "C	
Bureau of Mines Apparatus, cm 47; (1 1b vt) 4 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg 20	Refrective Index, nj. no. no. 1.4752 no.	
Friction Pendulum Test: Steel Shoe Explodes Fiber Shoe	Vecuum Stability Test: cc/40 Hrs, at 90°C	
Rifle Bullet Impact Test: Trials % Explosions Partials	100°C cc/gm 1.9 120°C 135°C 150°C	
Burned Unaffected	200 Grem Bomb Send Test: Sand, gm 43-7	
Explosion Temperature: *C Seconds, 0.1 (no cop used) 1 5 Ignites 235 10	Sensitivity to Initiation: Minimum Detanating Charge, gm Mercury Fulminate Lead Azide Tetryl	
15 20	Ballistic Morter, % TNT: (a) 136	
·	Treuzi Test, % TNT: (b) 140	
75°C International Host Test:           % Loss in 48 Hrs           100°C Heet Test:           % Loss, 1st 48 Hrs           2.5           % Lrss, 2nd 48 Hrs           1.8	Plate Deni Test: Method Condition Confined Density, gm/cc Brisonce, % TNT	
Explosion in 100 Hrs None Flemmebility Index:	Detenation Rate: Confinement	
Hygrescopicity: % 30°C, 90% RH 0.07	Condition Charge Diameter, in.	
Veletility: 60°C, mg/cm <sup>2</sup> /hr 24	Density, gm/cc Rate, meters/second	

### AMCP 706-177 Metriol Trinitrate (MTN) Liquid (or Trime+hylolethane Trinitrate)

#### Metrici Trinitrate (NTN) Liquid

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Fragmentation Test:	Sheped Cherge Effectiveness, TNT = 100:				
22 mm HE, M71 Projectile, Let WC-91: Density, gm/cc	Glass Cones Sine! Cones Hole Volume				
Charge Wr, ib	Hole Depth				
Total No. of Fragments: For TNT	Color: Oily, slightly turbid				
For Subject HE	Principel Uses: Ingredient of rocket and				
3 (ach HE, M43A1 Projectile, Let KC-3: Density, gm/cc Charge Wt, Ib	double base propellants				
Total No. 35 Fragmants: For TNT	Alethod of Looding:				
For Subject HE	Looding Density: gm/cc				
Fregment Velocity: (t/sec					
At 9 ft At 25% fi	Storage:				
Density, gm/cc	Method Liquid				
Hust (Rolative to TNT):	Hazard Ckes (Quantity-Distance)				
Air: Peak Pressure	Compatibility Group				
Impulse Energy	Exucation				
Air, Ceofined: Impulse	Solubility in Water, gm/100 gm, at:				
Under Weter: Peak Fressure	25 <sup>0</sup> C < 0.015 60 <sup>0</sup> C < 0.015				
Impulse	Heat of:				
Energy	Combustion, cal/gm 2642				
Underground: Peak Pressure	Hydrolysie, # Acid:				
Impulse Energy	10 Cays at 22°C 0.038 5 days at 60°C 0.115				

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#### Metriol Trinit.ste (MTN) Liquid

#### Preparation:

Metricl (trimethylolmethylmethane) is obtained by the following procedure, based on work by flosseus (Annalen 276, 76 (1893):

Into a 5 liter round bottom finsk is weighed 2700 gms of water. To this are added 267 gms of 36% formaldehyde and 60 gms of propionaldehyde. The mixture is stirred for a few seconds. To the mixture is added 150 gms of calcium oxide previously slaked with 600 gms of water. The mixture is heated in boiling water for four hours, and then allowed to cool spontaneously overnight. After filtering off the insoluble calcium hydroxide, the solution is heated and treated with a saturated aqueous solution of oxalic acid to precipitate all the calcium. The precipitated calcium oxilate is filtered off, and the pale-yellow filtrate concentrated as much as possible on the steam bath to a thick lemon-yellow symp. After dissolving in absolute alcohol, the solution is filtered and concentrated in the steam bath to about twice the volume of the concentrated symp. The solution is then chilled in a cold box to hasten crystallization. After allowing it to warm up to just above 0°C, the mixture is filtered. The resulting product is not sufficiently pure and is recrystallized from absolute alcohol. The melting point of the product (40.3 gm) is then about 196°C (Mosseus gives 199°C).

Metricl is nitrated by cerefully mixing it with 3.5 parts of  $65/35 \text{ HNO}_2/\text{H}_2SO_4$  muintained at 20°C, stirring for 30 minutes, cooling to 5°C, and pouring the reaction mixture on ice. It is extracted with ether, water-washed, and adjusted to pH 7 by shaking with a sodium bicarbonate solution and again water-washed three times. It is then dried with calcium chloride, filtered, and freed of ether by bubbling with dry air until minimal rate of loss in weight is attained. "... yield is 88% of the theoretical. The product has a nitrate-nitrogen content of 16.35% (calculated: 16.47%). Its refractive index at 25°C is 1.4752.

#### Origin:

MIN, according to Italian sources, was first prepared and patented by Bombrini-Parodi-Delfino Company of Italy under the name "metriolo." A German Patent of 1927 also describes the proparation and gives some properties. This compound was known in France before World War II under the name of "Nitrorentsglycerin" and Burlot and Thomas determined its heat of combustion (Ref b).

#### References: 44

(a) A. H. Blatt, <u>Compilation of Data on Organic Explosives</u>, OSRD Kepert No. 2014, 29 February 1944.

(b) E. Burlot and M. Thomas, Men poudr 29, 262 (1939).

(c) Also see the following Picatinny Arsenal Technical Reports on Metriol Trinitrate: 1616 and 1817.

<sup>44</sup>See footnote 1, page 10.

Minol-2

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Comp. ultion: %	Molecular Weight:	71
	Cxygen Belence:	
Ammonium Nitrate 40	CO- %	- 38
TNT 40	CO %	-20
Alumninum 20	Density: gm/cc	1.62-1.68
	Molting Faint: "C	
C/H Rutio	Freezing Point: "C	
Impoct Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 35	Boiling Point: "C	
Sample Wt 20 mg	Refrective Index, no	
Picatinny Arsenal Apparatus, in. 13 Sample Wt, mg 17	ns	
Sample Wt, mg 1?	n <sub>20</sub>	
Fristian Pandulum Test:		
Steel Shoe	Vacuum Stability Test:	
Steet Shoe	cc/40 Hrs, at 90°C	
	100°C	
Rifie Bullet Impoct Lat: Truzis	120°C	2.1
%	135°C	C. 1
Explosions	135°C	
Partiels	130°C	
Burned	200 Grean Bernb Send Test:	
Unaffected	Sond, gm	
Explosion Temperature: -C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)	Minimum Detonating Charge,	gm
1 8 Turdaya 197	Mercury Sulminate	
5 Ignites 435	Lead A zide	
10	Tetryi	
15 20	Beilistic Morter, % TNT: (a)	143
	Trouzi Test, % TNT: (b)	165
<ul> <li>'5 C International Heat Test:</li> <li>% Loss in 48 Hrs</li> </ul>	Plete Dent Test: (c)	
	Method	В
100°C fleet Test:	Condition	Pressed
% Loss, 1st 48 Hrs	Confined	No
% Loss, 2nd 48 Hrs	Density, gm/cc	1.73
Explosion in 300 Hrs	Brisance, % TNT	66
formebility index: 100	Detenation Rate: (d)     Confinement	None
	Condition	Cast
lygroscopicity: %	Charge Diameter, in.	1.6
	Density, gm/cc	1.63
<b>eletility</b> :		** ***

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#### AMCP 706-177

Boster Ser Pasy Test: Condition (e) Pressed Decomposition Ec Oxygen, atoms/sec (Z/sec) Tetryl, gm 100 Heat, kilocalorie/mole
 (ΔH, kcal/mol) 1.46 Wax, in. for 50% Detonation Temperature Ronge, \*C Wax. Sin 1.74 Phase Density, gm/cc (f) 3160 Heat of: (f) Armer Plate Impact Test: Combustion, cal/gm 1620 Explosion, cal/gm 60 mm Morter Projectile: 50% Inert, Velocity, ft/sec Gas Volume, cc/gm 828 Formation, col/gm Aluminum Fineness Fusion, col/g 500-Ib General Purpose Beml Specific Heat: Lal/gn://C Plate Thickness, inches At -50 0.30 1.74 Density; gm/cc 1 11,4 11/2 13; Burning Rate: cm/sec Bomb Drop Tost: Thermal Conductivity: col/sec/cm/\*C (b) 16.5 x 10<sup>-4</sup> T7, 2000-16 Semi-Armer-Piercing B nb vs Ca 1.74 Density, gm/cc isx Safe Drop, ft Coefficient of Expe Linear, %/\*C •: 500-K Seneral Purpose Bemb vs Concrete: Volume, %/\*C Heigh\*, ft Trials Hardness, Mohs' Scale: Unoffected Low Order (b) Young's Modulus:  $5.03 \times 10^{10}$ 0.73 × 10<sup>6</sup> High Order E', dynes/cm² E. Ib/inch<sup>2</sup> 1000-Ib General Purpose Bomb v3 Concrete: Density, gm/cc 1.66 Height, ft Compressive Strength: Ib/inch<sup>2</sup> (b) 1910-2070 Triais 1.68 Density, gm/cc Unoffected Vapor Pressure: \*C Low Order mm Mercury High Order

Minol-2

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#### Minol-2 AMCP 706-177 Fre ntetion Test: Shaped Charge Effectiveness, TNT = 100: 90 mm HE, M71 Projectile, Let WC-91: Gloss Cones Steel Cones Density, gm/cc **Hole Volume** Charge Wt, Ib Hole Depth Total No. of Fregments: Color: Gray For TNT For Subject HE Principal Uses: Bombs and depth charges 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib Totel No. of Fragments: Method of Londing: Cast For TNT For Subject HE Looding Density: gm/cc 1.62-1.68 Fregment Velocity: ft/sec At 9 ft At 25½ ft Storage: Density, gm/cc Method Dry Blast (Relative to TN'i): Hazard Class (Quantity-Distance) Class 9 Air: **Compatibility Group** Group I Peak Pressure 115 Impulse 116 Exudation Eneigy 133 Preparation: Air, Confined: Impulse 90 Minol is a castable mixture consisting of 40 percent TNT, 40 percent ammonium nitrate, and 20 percent powdexed aluminum and there-fore can be prepared by adding the dry in-gredients to molten TNT at 90°C under agita-tion. Minol also can be prepared by adding 25 parts of aluminum to 100 parts of 50/50 amatol previously prepared. **Under Water:** Pack Pressure **10**8 Impulse 126 Energy 140 Underground: Peok Pressure 134 Impulse 139 Energy 147

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AMCP 706-177

#### Minol-2

#### Origin:

Minols are British ternary explosives developed during World War II. There are three formulations:

Composition, %:	Minol-1	Minol-2	Minol-3
TNT	48	40	42
Ammonium Nitrate	42	40	38
Aluminum	10	20	20

### References: 45

(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives, Part III - Miscellaneous</u> <u>Sensitivity Tests; Performance Tests</u>, <u>OSRD</u> Report No. 5746, 27 December 1975.

(b) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Second Revision, NAVORD Report No. 87-46, 26 July 1946.

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) G. H. Messerly, <u>The Rate of Detonation of Various Explosive Compounds</u>, OSRD Report No. 1219, 22 February 1943.

M. D. Hurwitz, The Nate of Detonation of Various Compounds and Mixtures, OSRD Report No. 5611, 15 January 1946.

(e) L. C. Smith and S. R. Walton, <u>A Consideration of RDK/Wax Mixtures as a Substitute for</u> <u>Tetryl in Boosters</u>, NOL Memo 10,303, 15 June 1949.

(f) Committee of Div 2 and 8, HDRC, <u>Report on HEX and Tritonal</u>, OSRD No. 5406, 31 July 1945.
 (g) W. R. Tomlinson, Jr., <u>Blast Effects of Bomb Explosives</u>, PA Technical Div Lecture, 9 April 1948.

(h) Also see the following Picatinny Arsenal Technical Reports on Minol-2: 1585 and 1635.

45See footnote 1, page 10.

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MOX-1

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No.

Composition;		Molocular Weight:	40.6
% Oxidizing asent (Aumonium		Oxygen Belence:	
Perchlorste)	35.0	CO <sub>2</sub> %	-44
Aluminum, atomized	26.2	CO %	-37
Cupric Oxide	~~~~		
Magnesium, atomized	26.2 9.7	Density: gm/cc Pressed	2.0
Other ingredient (Tetryl) Calcium Stearate	1.9	Mahine Reinte %C	
Graphite, artificial	1.0	Melting Point: °C	
C/H Rotio		Freezing Point: "C	
Impact Soncitivity, 2 Kg Wt:		Boiling Point: *C	
Bureau of Mines Apparatus, cm		Petroving Index	
Somple Wt 20 mg Picatinny Arsenal Apparatus, in.	13	Refrective Index, no	
Sample Wt, mg	22	na	
		n	
Friction Pondulum Test:		Vocuum Stability Test:	
Steel Shoe	Detonetes	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	
			0.47
Rifle Sullet Impoct Test: Trials		120°C	
%		135°C	
Explosions		150°C	
Partials			
Burned		200 Grem Bomb Send Test:	
Unaffected		Sand, gm	10.6
Explosion Temperature: *C		Sensitivity to Initiation:	
Seconds, Q.1 (nu cap used)		Minimum Detonating Charge, gm	
1		Mercury Fulminate	
<b>5</b> 285		Lead Azide	0.20
10		Tetryi	0.25
15			· · · ·
20		Sellistic Merter, % TNT:	
75°C International Has? Tast:		Treuzi Test, % TNT:	
% Loss in 48 Hrs		Plate Dent Test:	
Discoloration, fumes, odor	None	Method	
100°C Heat Test:		Condition	
% Loss, 1st 48 Hrs	0.10	Confined	
% Loss, 2nd 48 Hrs	0.01	Density, gm/cc	
		Brisance, % TNT	
Explosion in 100 Hrs	None		
Flammability Index:		Confinement	
		Condition	
Hygroscopicky: %		Charge Diameter, in.	
		Density, gm/cc	
Volatility:		Rote, meters/second	

### AMCP 706-177

MOX-1

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Fregmentation Test:	Shaped Charge Effectiveness, TNT = 100:	
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth	
Total No. of Fragments: For TNT	Color: Gray powder mixture	-
For Subject HE <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	Principal Uses: Small caliber antiaircraft projectiles	
Tetal No. of Fragments: For TNT For Subject HE	Method of Loading: Pressed	
Fragment Velocity: ft/sec	Looding Seasily: gm/cc At 30,000 psi ~ 2.0	
At 25½ ft Density, gm/cc	Storege: Method Dry	
Blast (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9	
Air: Peak Pressure Impulse Energy	Compatibility Group Group I Bureau of Explosives Classification Class / Exudation	
Air, Confined: Impulse Under Water: Peak Pressure Impulse	Heat of:       4087         Combustion, cal/gm       2087         Explosion, cal/gm       2087         Gas volume, cc/gm       212         Performance Tests:       20 mm T215E1 Projectile:	
Energy Underground: Peak Pressure Impulse	NFOC Pressure Cube 35 APG Blast Cute 40 Activation Energy:	
Energy	kcal/mol 12.5 Temp, C 30C to 380 Time to ignition, seconds 1.78 x 10**	

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MOX-2B

AMCP 706-177

States and specific

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Composition: %		Molocular Vizight:	42
Oxidizing agent (Ammonium		Oxygen Belance:	
Perchlorate)	35.0	CO, %	-4 2
Aluminum, atomized	52.4	CO %	-43
Cupric Oxide			<b>^</b>
Magnesium, atomized Other ingredients*	9.7	Density: gm/cc Pressed	2.0
Calcium Stearate	1.9	Molting Point: *C	
Graphite, artificial	1.0		
5.8% REX and 3.9% TNT coated	n Ammonium Fullorate.	Freezing Point: °C	
Impact Sand' wity, 2 Kg Wt:		Boiling Point: *C	
Bureau of Mines Apparatus, cm			
Sample Wt 20 mg Picatinny Arsenal Apparatus, in.	12	Refractive Index, no	
Sample Wt, mg	24	na	
· · · ·		n <b>2</b>	
Friction Pondulum Test:		Vacuum Stability Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	
		- 100°C	0.21
Rifle Bullet Impoct Test: Trials		120°C	
Suctorian %		135°C	
Explosions		150°C	
Partials			
Bur ved		200 Gram Bomb Sand Test:	
Unoffacted		Sand, gm	11.5
Explosion Temperature: 'C	-	Sensitivity to Initiation:	
Seconds, 0.1 (n. cap used)		Minimum Detonating Charge, gm	
1		Mercury Fulminote	
5 375		Leod Azide	0.20
10		Tetryl	0.20
15			
20		Bellistic Morter, % TNT:	
73°C International Heat Test:		_ Trausi Test, % TNT:	
% Loss in 48 Hrs		Plate Dent Test:	
Discoloration. fumes, odor	None	Method	
100°C Heat Test:		Condition	
% Loss, 1st 48 Hirs	0.27	Confined	
% Loss, 2nd 48 Hrs	0.12	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TN1	
-		- Detenction Rete:	
Flammability Index:		Confinement	
		- Condition	
Hygruscopicity: %		Charge Diameter, in.	
		Density, gm/cc	
Veletility:		Rats, meters/second	

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MOX-2B

Fragmentative Test:			Shaped Cherge Effectiveness, TNT = 100:	
90 mm HE, M71 Projectile, Le Density, gm/cc Charge Wt, ib	# WC-91:		Glass Cones Steel Cones Hole Volume Hole Depth	
Total No. of Fragments: For TNT			Color:	Grey
For Subject HE 3 inch HE, M42A1 Projectile, (	Let KC-5:		Principal Uses: HE filler for small caprojectiles	aliber
Density, gm/cc Charge Wt, Ib				
Total No. of Fragments: For TNT			Mathod of Loading:	Pressed
For Subject HE			Looding Density: gm/cc	2.0
Fregment Velocity: ft/sec At 9 ft At 251/5 ft			Storoge:	
Density, gm/cc			Method	Dry
Blast (Relative to TNT):			Hazard Class (Quantity-Distance)	Class 9
Air: Bare Charge: Peck Pressure	Ew* 1.02	<u>EV#</u> 1.34	Compatibility Group Bureau of Explosives Class A	Group I
Impulse	1.08	1.41	Exudation	None
Energy Density, gm/cc Air, Confined: Impulse		1.96	Heat of: Combustion, cal/gm Explosion, cal/gm	484 14-72
Cased Charge in Air:**			Ges volume, cc/gm	22
Peak Pressure Impulse	1.09 1.16	1.44	Performance Tests:	
Energy			20 mm T215El Projectile:	
Density, gm/cc Underground:		1.98	NFOC Pressure Cube APG Blast Cube	29 30
Peck Pressure Impulse			Aviation Energy:	
Energy			kcel/mol	7.6
*Ew. equivalent weight as Ev, equivalent volume as			Temp. <sup>6</sup> C 340 1	x 10 <sup>-2</sup>
**Strong paper-base phenol:	ic case.			

MOX-2B

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Effect of Altitude, Charbe Diameter and D. gree of Confinement on Detonation Velocity\* (Reference g)

	One-In	ich Column	Two-Inch	Column
Simulated Altitude,	Confined	Unconfined	Confined	Unconfined
Feet	m/s	m/ a	m/s	n/s
Ground			4730	
30,000	Charge W	rould not	4530(3)	Charge would
60,000	proragate	detonation.	4430	not propa- gate detona-
90,000			4290	tion.
Average	• • •		4495	

\*Confined charge in 1/4" steel tube, AISI 1015 seamless, 1" diameter 18" long, and 2" diameter 7" long. All means were determined from sets of five values unless otherwise indicated by ( ). A 26 gm tetryl booster was used to initiate each charge.

### Average Fragment Velocity at Various Altitudes\* (g)

	Simulated Altitude, Feet				
Fxplosive	Charge Diameter, Inches	Ground m/s	30,000 m/s	60,000 m/s	<u>97,000</u> .√∎
MOX-2B, density,	1	2012	**	**	**
gm/cc 207	2	3314	3351	3247	**

\*Outside diameter 2.54"; inside dismeter 2.04"; length 7".

\*\*Charge would not propagate detonation.

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### AMCP 706-177

- Level

### MOX-3B

Composition:	Melecular Weight:	45.6
Oxidizing agent (Potassium Nitrate) 18	Oxygen Belance:	
Aluminum, atomized 50	CO. %	-52
Cupric Cxide	CO %	-52 -43
Magnesium, atomized		
Other ingredients* 32 Culcium Stearate** 2.0	Density: gm/cc Pressed	2.0
Graphite, artificial** 1.0		
*29.1% RDX, 0.9% wax, and 2.0% INT.	Melting Point: °C	
**Per cent adled.	Freezing Point: *C	
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	Boiling Point: "C	
Sample Wt 20 mg	Refrective Index, na	
Picatinny Arsena' Apparatus, in. 17 Sample Wt. ma 24	nB	
Sample Wt, mg 24	-	
	n <sup>2</sup>	
Friction Pendulum Test:	Vacuum Stebility Test:	
Steel Shoe Unaffected	cc/40 Hrs, at	
Fiber Shoe Unaffected	90°C	
Diffe Bullet Impered Tests Total	- 100°C	0.57
Rifle Bullet Impact Test: Trials	120°C	
Sur lasiana	135°C	
Explosions	150°C	
Partials		
Burned	200 Gram Bomb Sand Test:	
Unoffected	Sand, gm	33.2
Explosion Temperature: "C	Sensitivity to Initiation:	
Seconds, 0.1 (no cop used)	Minimum Detonating Charge, gm	
1	Mercury Fulminate	
5 540	Lead Azide	0.20
10		
15	Tetry!	0.15
20	Balli .:: Morter, % TNT:	
75°C International Heat Test:	Trouzi Toot, % TNY:	
% Loss in 48 Hrs	Plais Dont Test:	
Discoloration, fumes, odor None	Method	
100°C Heat Test:	Condition	
% Loss, 1st 48 Hrs 0.35	Confined	
% Loss, 2nd 48 Hrs 0.13	Density, gm/cc	
•	Brisance, % TNIT	
Explosion in 100 Hrs None		
Flammability Index:	- Deconstion Rete:	
	Confinement	
	- Condition	
Museus and a law of		
Hygrescopicity: %	Charge Diameter, in.	
Hygrescopicity: %		

<u>MOX-3B</u>

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Fragmentation Test:	Shaped Charge Effectiveness, TNT	= 100:
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones St Hole Volume Hole Depth	eel Cones
Total No. of Fragmants: For TNT	Color: Gray por	der mixture
For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib	Principei Uses: Small caliber projectiles	entiaircraft
Tetal No. of Fragments: For TNT For Subject HE	Method of Looding:	Pressed
Fregment Velocity: ft/sec At 9 ft	Leeding Dessity: gm/cc At 30,000 psi	~2.0
At 25½ ft Densit/, gm/cc	Storege: Method	Dry
liest (Relative to TNT):	Hazard Class (Quantity-Distance	) Class 9
Air: Peok Pressure Impulse Energy	Compatibility Group Bureau of Expl	Group I osives Class A
Air, Confined: Impulse Under Water: Peak Pressure Impulse Energy	Heat of: Combustion, cal/gm Explosion, cal/gm Gas volume, cc/gm <u>Performance Tests:</u> 20 mm T215EL Projectile:	4331 980 232
Underground: Pook Pressure Impulse Energy	NFOC Pressure Cube APG Blast Cube Activation Energy: kcal/mol V Temp, C dd	37 52 alues not included ue to erratic ig- ition under condi-

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### AMCP 706-177

MOX-48

Composition: %	Moleculer Weigini:		<u>18</u>	
	18 Oxygen Belonce:			7
· · · · · · · · · · · · · · · · · · ·	50 CO, %		-53	
	CO %		-43	
	32 Density: or //rc			-1
	32 Density: g: ,/cc	Pressed	2.0	
Graphite, artificial** 1	.0 Melting Point: "C			
*29.1% RDX, 0.9% wax, and 2.0% TNT. **Per cent added.	Freezing Point: "C			1
Impact Scasitivity, 2 Kg Wt: Bureou of Mines Apparatus, cm 78	Boiling Point: "C			
Bureau of Mines Apparatus, cm 78 Sample Wt 20 mg	Refrective Index, no			
Picatinny Arsenal Apparatus, in. 18	na			
Somple Wt, mg 26	n as n 20	•		
Friction Pandulum Yest:	Vocuum Stability Test:			
Steel Shoe Spark				
Fiber Shoe Unaff				
Rifle Bullet Impact Teet: Trials	100°C		0.67	
• • • • • • • • • • • • • • • • • • • •	120°C'			
% Explosions	135°C			
•	150°C			
Partials				-
Burned	200 Grem Bomb Sand Te	let:		
Unoffected	Sand, gm		33.6	
Explosion Tempsrature: 'C	Sensitivity to Initiation:			- N.
Seconds, 0.1 (no cap used)	Minimum Detonating	Charge, gm		
	Mercury Fulminate			
5 610	Lead Azide		0.20	1
10	Tetryl		0.15	
15				_
20	Bellistic Morter, % TN1	ľ:		
	Treuzi Test, % TNT-			
75°C International Heat Test: % 1.3s in 48 Hrs	Plate Dant Test:			
Discoloration, funes, odor N	one Method			
100°C Hest Test:	Condition			
% Loss, ist 48 Hrs 0.22	Confined			
% Loss, 2nd 48 Hrs 0.12	Density, gm/cc			
Explosion in 100 Hrs None	Brisance, % TNT			
	Detenstion Rate:			-
Flammability index:	Confinement			
• • • • • • • • • • • • • • • • • • • •	Condition			
Hygroscopicity: %				
	Charge Diameter, in.			
Veletility:	Density, gm/cc			
· ••••••••••••••••••••••••••••••••••••	Rote, meters/second			1

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MCX-4B

### AMCP 706-177

Gloss Cones Hole Volume Hole Depth Celor: Principel Uses: Sumili cal projectil Mechod ef Lessiling: Lessing Density: gm/cc At 30,000 pmi Storage: Method Hozard Class (Quantity-Dis	Gray powder mixture iber entiaircraft es Pressed
Color: Principal Uses: Small cal projectil Maxinod of Leading: Looding Density: gm/cc At 30,000 psi Storage: Method	iber entiaircraft es Pressed 
Principal Uses: Sumil cal projectil Maximod of Lessing: Lessing Density: gm/cc At 30,000 pmi Storage: Adethod	iber entiaircraft es Pressed
projecti Maxing of Looking: Looding Density: gm/cc At 30,000 psi Storege: Method	es Pressed ~[] D Dry
Mechad of Unsking: Looding Density: gm/cc At 30,000 psi Storege: Method	Pressed - 1 D Dry
Leeding Density: gm/cc At 30,000 ps1 Storege: Method	<b>~</b> ∏ D Dry
At 30,000 psi Storege: Method	Dry
Method	
Hozard Class (Quantity Dis	
	itance) Class 9
Compatibility Group	Group I Bureau of Explosive Class A
Heat of: Computation, cal/gam	4392
Gas volure, cc/gm	709 <b>20</b> 8
Performance Tests: 20 mm T215E1 Project	ile:
NFOC Pressure Cube APG Blast Cube	43 53
Aviation Energy:	
Temp, <sup>o</sup> C	Values not included due to erratic igni- tion under conditions of test.
	Explosion: csl/gm Gas volute, cc/gm Performance Tests: 20 mm T215E1 Project NFOC Pressure Cube APG Blast Cube Aviation Energy: kcsl/mol Temp, °C Time to ignition,

AMCP 706-177

MOX-6B

Composition:		Malecular Weight:	43
% Oxidizing agent		Oxygen Belence:	
Aluminum, atomized	49.2	CO. %	-50
Cupric Oxide	19.7	CO %	-30
Magnesium, at.mized Other ingredients*	29.6		
Calcium Stearate	29.0	Density: gm/cc	
Graphite, artificial *28.75 RDX coated, C.95 wax.	1.5	Melting Point: °C	
C/H Rotio		Freezing Voint: "C	
Impact Sensitivity, 2 Kg Wt:	~u	Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	78	Refractive Index, no	
Picatinny Arsenal Apparatus, in. Sample Wt, mg	19 27	nS	
Junipation and the second seco	<b>c</b> 1		
		n‰	
Friction Pondulum Text:		Vacuum Stebility Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaifected	90°C	
		- 100°C	0.43
Rifle Bullet Impact Test: Tricls		120°C	-
Suplations %		135°C	
Explosions		150°C	
Partials			
Burned		200 Gram Bomb Sand Test:	
Unaffected		Sand, gm	10.8
Explosion Temps.ature: °C		Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, ym	
1		Mercury Full-ningte	
5 510		Lead Azide	0.20
10		Tetryl	0.16
15		1 - 1 I YI	0.10
20		Ballistic Morter, % 167:	
75°C International Heat Test:		- Trauzi Test, % TNT:	
Loss in 48 Hrs Discoloration, fumes. odor	0.02/10 gm None	Flate Dent Test: Method	
109'C Heat Test:		Condition	
% Loss, 1st 48 Hrs	0.00	Confined	
So Loss, 2nd 48 Hrs	0.00	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TNT	
Flammability Index:		Detonation Rate:	
		Confinement	
Hygrescopicity: %		Condition	
50°C, 90% RH, two weeks	0.79	Charge Diorneter, in.	
Voletility:		Density, gm/cc	
Y CHERINITY :		Rate, meters/second	

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AMCP 706-177 <u>мох-бв</u> **Fregmontation** Test: Sheped Charge Effectiveness, TNT = 100: 90 mm HE, M71 Projectile, Let WC-91: . Glass Cones Steel Cones Density, gm/cc Hole Volume Charge Wt, Ib Hole Depth **Total No. of Fragments:** Color: Gray powder mixture For TNT For Subject HE Principal Uses: Small caliber antiaircraft 3 inch HE, M42A1 Projectile, Lat KC-5: projectiles Density, gm/cc Charge Wt, Ib Total No. of Fragments: Method of Londing: Pressed For TNT For Subject HE Loading Density: gm/cc At 30,000 psi Fregment Velocity: ft/sec At 9 ft At 251/2 ft ~2.0 Storage: Density, gm/cc Method Dry Blast (Relative My TNT); Hazard Class (Quantity-Distance) Class 9 **Compatibility Group** Grc p I A.ie: Bureau of Explosives Peak Pressure Impulse Class A Energy Heat of: Air, Confined: Impulse Combustion, cal/gm Explosion, cal/gm Cas volume. cc/gm 4293 750 204 Under Weter: Peak Pressure Impulse Activation Emergy: Energy kcal/mol Values not included 'emp, C due to erratic igni-Time to ignition, tion under conditions seconds of test. Underground: Peak Pressure impulse Energy

#### AMCP 706-177

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#### MOX-1; MOX-2B; MOX-3b; MOX-4B; MOX-6B

#### Preparation:

The various ingredients used in the preparation of MOX explosives are coated separately as follows:

Dichromated Atomized Aluminum - Seventy-five grams of chemically pure grade sodium dichromate is dissolved in 1500 milliliters of water at  $100^{\circ}$ C under mechanical agitation. Six hundred grams of the atomized aluminum powder is added gradually (2 to 3 minutes) and stirring is continued for half an hour. The dichromated metal is filtered, washed with water (15 to 20 times) until the washings show only a slight cloudiness with silver nitrate. The water-wat product is then dried in an oven at 50°C. The dried material is hand-rolled to reduce any conglomerates, and blended before use.

<u>Wax-Coated RDX</u> - Eighteen grams of molten Be Square Special Wax (manufacturer  $> 180^{\circ}$  to 185° Fahrenheit grade amber) is added to 582 grams of finely divided RDX (water precipitated from scetone solution) in a water slurry under mechanical agitation. The temperature of the wax-RDX slurry is maintained above the melting point of the wax (about  $>0^{\circ}$ C). The stirring is continued for half an hour. After cooling to 50°C, the wax-coated RDX is recovered by filtration in a Büchner funnel and dried in air. The RDX thus coated and presumed to be 3% waxed RDX or a 97/3 RDX/wax mixture is hend-rolled to crush any conglomerates formed, and bleuded by hand before use.

INT-Coated Barium Nitrate - Thirty grams of TNT in alcohol solution is added to 270 grams of barium nitrate in an alcohol slurry under agitation. The temperature of the TNT-barium nitrate mixture is maintained at 80°C and stirring is continued until most of the alcohol is evaporated. The coated material is spread in a thin layer on a tray to dry in air overnight. The barium nitrate thus coated with 10% TNT is reduced to an intimate mixture by hand-rolling ard blending before use.

<u>INT-Coated Potascium Nitrate</u> - The INT-coated potassium nitrate is prepared by the same procedure as is used for coating barium nitrate.

<u>ADX/INT-Coated Annonium Perchlorate</u> - The ammonium perchlorate is coated by dissolving the supropriate weights of RDX and INT in hot sicohol. After add. the ammonium perchlorate, the intry is stirred until most of the solvent is evaporated. The treated ammonium perchlorate spread on a tray to dry overnight. Agglomerates formed during the process are crushed by band-rolling and blending the mixture before use.

<u>INT-Joated RDX</u> - Sixty grams of rolten INT are added to a water slurry of 540 grams of finely divided RDX (water precipitated from acetone solution) under mechanical agitation. The temperature of the INT-RDX slurry is maintained at about  $90^{\circ}$ C and stirring is continued for hell an hour. After cooling to about  $50^{\circ}$ C, the INT-coated RDX is recovered by filtration. The RDX thus treated, and presumed to be 10% coated or a 90/10 RDX/INT mixture, is further blended by hand after rolling to crush any aggregates formed during the process.

The HOX explosive mixtures are prepared by blending the appropriate weights of the dry ingredients in a Patterson-Kelly twin-shell blender for at legst 30 minutes.

#### Origin:

MOX type explosive mixtures were developed beginning in 1950 by National Northern, technicol division of the National Fireworks Ordnance Corporation, West Hanover, Massachusetts.

#### MOX-1; MOX-2B; MOX-3B; MOX-4B; MOX-63

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References: 46

(a) A. O. Mirerchi and A. T. Wilson. Development of MOX Explosives for Improved 20 mm Ammunition, Navy Contract NOrd-10975, Task 1, National Fireworks Ordnance Corporation; First Yearly Summary, August 1950 to August 1951.

(b) A. T. Wilson, <u>Development of MOX Explosives</u>: Various Oxidants in MOX, First Progress Report NFOC-6, Navy Contract Nord-12382, National Fireworks Ordnance Corporation, December 1952.

(c) A. O. Mirarchi, <u>Properties of Explosives: Theory of the MOX Explosion</u>, First Progress Report NFOC-10, Navy Contract NOrd-11393, National Firevorks Ordnance Corporation, December 1952.

(d) A. O. Mirarchi, Properties of Explosives, MOX Explosives in Various Atmospheres, First Progress Report NFOC-9, Navy Contract NOrd-11393, National Fireworks Ordnance Corporation, 1952.

(e) A. T. Wilson, <u>Development of MCX Explosives</u>: <u>Composition Variations</u>, First Progress Report NFOC-7, Navy Contract NOrd-12382, National Fireworks Ordnance Corporation, 1952.

(1) A. T. Wilson, <u>Development of MOX Explosives: Various Oxidants in MOX</u>, Second Progress Report NFOC-14, Navy Contract NOrd-13684, National Fireworks Ordnance Corporation, October 1953.

(g) A. W. O'Brien, Jr., C. W. Plummer, R. P. Woodburn and V. Philipchuk, <u>Detonation</u> Velocity Determinations and Fragment Velocity Determinations of Varied Explosive Systems and Conditions, National Northern Corporation Final Summary Report NNC-F-13, February 1958 (Contract DAT-19-020-501-ORD-(P)-58).

(h) P. Z. Kalanski, <u>Air Blast Evaluation of MOX-2B Cased and Bare Charges</u>, NAVORD Report No. 3755, 5 April 1956.

(i) Also see the following Picatinny Arsenal Technical Reports on MOX Explosives: 1935, 1969, 2204. 2205.

46See footnote 1, p.

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Nitrocellulose, \_2.6% (NC)

Composition: % Malecular Weight: (272.39)<sub>n</sub> Oxygen Falence: C H 26.46 CO % **-3**5 0.6 2.78 <sup>i</sup>2¦ x 12.60 58.16 N O Density: gm/cc n X=ONO2 Melting Point: "C Decomposes Freezing Point: \*C C/H Ratio 0.23 **Boiling Point:** "C Impact Sensitivity, 2 Kg Wt: 8 Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Refractive Index, nº 35 n25 Sample Wt, mg **n**20 Friction Pondulum Test: Vocuum Stability Test: cc/40 Hrs, at 90°C Steel Shoe 0.17 <sup>p</sup>iter Shoe 100°C 1.0 Rifle Bulket Impact Test: Trials 120°C 16 hours 11.+ % 135°C Explosions 150°C Partials 200 Grem Bomb Sand Test: Burned Sand, gm 45.0 Unaffected Sensitivity to Initiation: Explosion Temperature: °C Minimum Detonating Charge, gm Seconds, 0.1 (no cap used) **Mercury Fulminate** 170 5 Decomposes Lead Azide 0.10 10 Tetryl 15 Ballistic Morter, % TNT: 20 Treuzi Test, % TNT: 75°C International Heat Test: Plate Dant Test: % Loss in 48 Hrs Method Condition 100°C Heet Test: Confined % Loss, 1st 48 Hrs Density, gm/cc % Loss, 2nd 48 Hrs Brisonce, % TNT Explosion in 100 Hrs Det notion Rete: Flammability Index: Confinement Condition Hygroscopicity: % 30°C, 90% RH 3 Charge Diameter, in. Density, gm/cc Velutility: 60°C, mg/cm<sup>2</sup>/hr 0.0 Rate, meters/second

226

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1. A. 1.

Composition: H o'	Molecular Weight:	(286 <b>. 34)</b> n
70	Oxygen Balance: CO <sub>2</sub> % CO %	-29 4.7
0 58.74 0 X=0NO2	Density: gm/cc	
	Meiting Point: °C	Decomposes
C/H Ratio 0.23	-Ju Freezing Point: °C	
mpact Sonaitivity, 2 Kg Wt:	Boiling Point: "C	
Bureau of Mines Apparatus, cm 9 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 3 Sample Wt, mg 5		កដ្ឋ កន្ល
Friction Pendulum Test:	Verwum	Test:
Steel Shoe Fiber Shoe	cc/40 H.s, ot 50°C 100°C	0.42 1.5
Rifie Bullet Impact Test: Trials	100°C	1.5
<b>%</b>	135°C	
Explosions	150°C	
Partials Burned	200 Gram Somp Se	ad Test:
Unaffected	Sand, gm	49.0
Explosion Temperature: °C Seconds, 0.1 (no cap used) 1	Secsitivity to Initin Minimum Deton Mercury Fulir	oting Charpe, am nin.set
5 230 10	Lead Azide Tetryl	0.10
15 20	Ballistic Mortor, %	INT: 125
	Trouzi Test, % Th	۲:
75°C International Heat Test: % Loss in 48 Hrs	Plate Eant Test: Method	
100°C Heat Test:	Condition	
% Loss, 1st 48 Irs 0-3	Confined	
% Loss, 2nd 48 Hrs 0.0	Density, gm/cc	-
Explosion in 100 Hrs None		
Flammability Index:	Detenstion Rate:	
Hygroscopicity: % 30°C, 90% RH ~	Condition	
	<sup>2</sup> Charge Diamete	r, m.
	Density, gm/cc	1.20

### Nitrocellulose, 13.45% N (NC)

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### Nitrocellulose, 14.14% N (NC)

Composition:	Molecular Weight:	(297.15) <sub>n</sub>
с 24.25 н 2.37 н <sub>2</sub> с , к	Oxygen Balance: CO: % েট %	<b>-24</b> 6
$\begin{array}{c ccccc} N & 14.14 & X & H \\ o & 59.24 & O & H \\ X=ONO_2 & & V \end{array}$	Density: gm/cc	1.65-1.70
- // *	Melting Point: °C	Десощовев
C/H Ratio 0.23	Freezing Point: "C	
Impact Sansitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 8	Boiling Point: °C	
Sample Wt 20 mg Picatinny Arsenol Apparatus, in. 3 Sample Wt, mg 5	Refractive Index, ng ng ng	
Friction Pendulum Test:	Vacuum Stability Test:	
Steel Shoe Fiber Shoe	cc/40 Hrs, at 90°C	1.46
		11.+
Rifle Bullet Impact Test: Trials	127°C 16 hours	11.+
% Explosions	135 °C	
Partials	150°C	
Burned	200 Gram Bomb Sand Test:	
Unaffected	Sand, gm	52.3
Explacion Temperature: °C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)	Minimum Detonating Charge	e, gm
1 5	Mercury Fulminate Leod Azide	C.10
10	Tetrvi	C. 10
15	Bellistic Mortes, % TNT:	
20	Trouzi Test, % TNT:	
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Test:	
	Method Condition	
100°C Heat Test:	Confined	
% Loss, 1st 48 Hrs % Loss, 2nd 43 Hrs	Density, cm/cc	
Explosion in 100 Hrs	Brisance, % TNT	
Flemmability Index:	Detention Rote: Confinement	
	Condition	
Hygrescopicity: % 30°C, 90% RH 🛹 1	Charge Diameter, in.	
Voletility: 60°C, mg/cm <sup>2</sup> /hr 0.0	Density, gm/cc	
Volatility: $60^{\circ}$ C, mg/cm <sup>-</sup> /hr 0.0	Rate, meters/second	

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### Nitrocellulose (NC)

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Fregmentation Test:	Sheped Charge Effectiveness, TNT = 100:
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth
Total No. of Fragments: For TNT	Color: Valte
For Subject HE <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	Principel Uses: Pyroxylin (12% N). blasting explosives; pyrocellulose (12.60% N), smokeless powder; guncotton (13.35% N minimum), propellants
Tetal No. of Fragments: For TNT For Subject HE	Mathod of Looding:
Fregment Velecity: ft/sec At 9 ft At 25½ fr	Looding Density: gm/cc Storuge:
Density, gm/cc Blast (Relative to TNT):	Method Wet (8% to 30% watch) Hozard Class (Quantity-Distance) Class 12
Air: Peak Prescure Impulse Energy	Compatibility Group Group M (wet) Exudation None
Aiz, Cenfiaci' Impulse Under Water:	<u>Heat of:</u> Combustion, cal/gm 2409* 2313** 2228*** Explosion, cal/gm 855* 965** 1058*** Cas Volume, cc/gm 919* 883** 853***
Peak Pressure Impulse Energy	Formation, cal/gm 617* 561** 513*** * 12.6% N ** 13.45% N *** 14.14% N
Underground: Peak Pressure Impulse Energy	Vapor Pressure:       OC     mm Mercury       25     0.00
	60 0.00

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Nitrocellulose (NC)

Solubility in Water, gm/100 gm, at:	12.6% N	13.45% N	14.0% N
25 <sup>0</sup> C 60 <sup>0</sup> C	Insoluble Insoluble	Insoluble Insoluble	Insoluble Insoluble
Solubility, gm/100 gm, 25°C, in:			
Ether	Inscluble	Insoluble	Insoluble
Alcohol	Very slight- ly roluble	Practically insoluble	Insoluble
2:1-Ether:Alcohol	Soluble	Slightly soluble (6%-11%)	Practically insoluble (1 + 3)
Acetone	Soluble	Soluble	Soluble
24.)-Hour Hydrolysis Test, <u> 5 Mitric Aci</u>	1.22	1.03	

#### Preparation of Nitrocellulose from Cotton Linters: (Imboratory Procedure)

Nitration: Second cut cotton linters, previously dried to a moisture content of less than 0.5%, are nitrated by immersion in mixed acid under the following conditions:

Ratio of Mixed Acid to cotton 55 to 1

Composition of Mixed Acid (approximate)

- a. for 12.6% N: H<sub>2</sub>SO<sub>4</sub> 63.5%, HNO<sub>3</sub> 21%, H<sub>2</sub>O 15.5%
- b. for 13.4% N: H<sub>2</sub>SO4 68%, HNO3 22%, H<sub>2</sub>O 10.0%

Temperature of acid at the start 34°C

Time of nitration 24 minutes

During the nitration period the mixture is turned over occasionally to keep the acid homogeneous. The mixture is then filtered on a Buchner funnel with suction for about three minutes and then drowned rapidly with strong hand stirring in at least 50 volumes of cold water. After the nitrocellulose has settled, most of the water is decanted and fresh water added. The nitrocell loss-water mixture is boiled and the acidity adjusted to 0.25% to 0.50% as  $H_2SO_4$ . The sour boil is continued for at least 24 hours for pyrocellulose and at least 40 hours for gun-cotton. Additional boiling with changes of water are made in accordance with the governing specification (JAN-N-244).

<u>Pulping:</u> The nitrocellulose is then pulped in a laboratory Holland type paper beater. Enough sodium carbonate is added to keep the reaction faintly alkaline to phenolphthalein. Pulping is continued to the desired degree of fineness.

<u>Poaching:</u> After washing the nitrocellulose from the beater, the mixture is filtered and the product boiled for 4 hours with fresh water while stirring mechanically. From time to time a little codium carbonate solution is added to maintain the mixture faintly alkaline (s) phenolphthalein. The water is decanted and the boiling continued. According to the specification, the total boiling treatment with poschi. is as follows:

### Nitrocellulose (NC)

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- 4 hours boiling with or without sodium carbonate
- 2 hours boiling without sodium carbonate
- 1 hour boiling without sodium carbonate
- 1 hour boiling without sodium carbonate.
- Each boil is followed by settling and change of water.

<u>Washing:</u> The nitrocellulose is then washed by mechanical agitation with water. A minimum of two washes are given. If a sample taken after the water washes gives a minimum test of 35 minutes in the  $65.5^{\circ}$ C Heat Test and 30 minutes in the  $13^{4}.5^{\circ}$ C Heat Test, the nitrocellulose is satisfactorily stabilized. Otherwise additional washes should be given.

#### Origin:

Cellulose occurs in nature. It is wood fiber, cell wall and the structural material of all plants. Cotton fiber is pure cellulose. Nitrocellulose was discovered about 1847 by C. F. Schonbein at Basel & d R. Bottger at Frankfort-on-the-Main independently of each other when cotton was nitrated. T. J. Pelouze had nitrated paper earlier (1838) and was probably the first to prepare nitrocellulose.

Pyroxylin or collodion, which is soluble in a mixture of ether and ethanol, contains from 8% to 12% nitrogen. It is used in the manufacture of celluloid and in composite blasting explosive.

Pyrocellulose, a type of nitrocellulose of 12.6% nitrogen content, complete y soluble in a mixture of 2 parts ether and one part ethanol, was developed by Mendeleev ( ,1-1895). This material, when colloided, formed the first smokeleds powder for military use in the United States (1898).

Guncotton for military purposes they contains a minimum of 13.35% nitrogen. It is only slightly soluble in ether-ethanol, but completely soluble in acetone. Principal use is in flashless powders and as flame carriers. 14.14% N nitrocellulose represents a theoretical limit.

In the manufacture of propellants, there is used a mixture of pyrocellulose and guncotton (blonded nitrocellulose) of 13.15% to 13.25% nitrogen content.

#### restruction by Chemical Decomposition:

Nitrocellulose is decomposed by adding it, with stirring, to 5 times its weight of 10% sodium hydroxide heated to  $70^{\circ}$ C. Stirring is continued for 15 minutes after all the nitrocellulose bas been added.

### References: 47

(a) See the following Picatinn/ Argonal Technical Reports on Nitrocellulose:

<sup>47</sup>See foutnote 1, page 10.

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P 706-17	7			Nitroce	llulose	(NC)			
<u>0</u>	1	2	<u>3</u>	4	٤	6	Ţ	<u>8</u>	2
10 390 420 660 730 960 1029 1150 1300 1350 1410 1430 1580 1660 1830 1990 2210	41 101, 23] 351, 551, 831, 851, 971, 1031, 1041, 1071, 1151, 1201, 1231, 1351,	72 332 402 542 552 652 652 652 652 652 652 1032 1242 1392 1642 1392 1642 1392 2102 2102	13 33 43 253 253 2753 2753 2753 2753 2753 2673 2753 2023 2023 2023 2023 2023 2023 2023 20	4 24 1174 3373 780 894 1074 1270 1389 4 1074 1389 4 1075 4 4 21 12824 12844 12754 12824	125 475 485 555 7965 1065 1265 1265 1265 1265 1265 1275 1845 1915 1955	86 576 586 796 916 1026 1206 1206 1256 1316 1516 1516 1516 1516 1516	167 327 407 717 787 987 1187 1267 1297 1267 1297 1327 1407 1427 1587 1637 1637 1637 1637 1817 1827 1847 2137	8 198 208 278 388 408 588 718 758 758 758 758 1058 1228 1238 1238 1238 1238 1478 1528 1638 1838 1838 1838 1838 1838 2098 2208	19 29 69 169 279 499 659 669 709 735 809 909 1159 1349 1399 1439 1449 1609 1869 2119 2189

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### Mitroglycerin (Liquid)

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Compatibles: %	Meleculer Weight: (C3H5H3C	) 227	
$C$ 15.9 $H_2C - 0NO_2$ H 2.2 $HC - 0NO_2$	Oxygen Belence: CO <sub>2</sub> % CO %	3.5 24.5	
N 18.5 $H_2C - 0NO_2$	Density: gm/cc 25°C, Liqu 20°C, Liqu	id 1.5	91. 96
0 63.4	Molting Point: "C Labile fo Stable fo	<b>2.2</b>	
C/H Ratie 0.109	Freezing Point: "C		
mpost Sensitivity, 2 Kg Wt: Bureau of Minrs Apparatus, cm 15	Beiling Peint: *C Decompos	<b>es 145</b>	
Sample Mt 20 mg	Refrective Index, na	1.4	732
Picatinny Arsenal Apparatus, in, 1 1b wt 1 Sample Wt, mg	n <u>2</u> n <u>2</u>	1.4	713
Priction Pandulum Tests	Vacuum Stability Test:		
Steel Shoe	cc/40 this, at		
Fiber Shoe	90°C cc/gm/6 hrs	1.6	
Life Buildt Impact Test: Trials	- 100°C cc/gm/16 hrs 120°C	11+	
% Explosions 100	135°C		
• • • •	150°C		
Portiols 0			
Burned 0 Unaffected 0	200 Gram Bamb Sand Test: Sond, gm Liquid metho	d 51.9	5
Explosion Temperature: *C Seconds, 0.1 (nu cap used) 1 5 Explodes 222 10	Ssochtvity So Initiatius: Minimum Detonoting Charge Mercury Fulminate Lead Azide Tetnyi	), gm	
15	Bellistic Morter, % THT: (a	) 140	
	Tocual Test, % This: (b		
18% : International Heat Test: 9. Loss in 48 Hrs	Plate Deal: Test: Method		
60° C Heut Test:	Condition		
96 Loss, 1st 48 H/c 3.€	Confined		
% Loss, 2nd 48 Hrs 3.5	Density, gm/cc		
Exp osion in 160 Hrs None	Brisonce, 16 TNT		
lomm billty index:	- Detanistion Rate: Confinement	Class	Steel
	Condition	Liquid	Liquid
<b>iygre</b> r <b>cepicity: % 30<sup>0</sup>℃,</b> 90% RH 0.06	Charge Diameter, in.	0.39	1.25
/eter	Density, gm/cc	1.6	1.6
	Rate, meters/second 1600-1		7700

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### Nitroglycerin (Liquid)

	er Sensitivity Test: adition			Decen position Equation: Oxygen, atoms/sec	10 <sup>17•3</sup>	10 <sup>19.2</sup>
Tet	ryi, gm			(Z/sec) Heat, kilocalorie/mole	41.4	45.0
Wa	ux, in. for 50% Detonation	1		(JH, kcal/mol)	41.4	47.0
Wa	x, gm			Temperature Ronge, °C	90-135	125-150
Der	ruity, gm/cc			Phase	Liquid	Liquid
Heat			1616	Armer Plate Impact Test:		
	nbustion, cal/gm plasion, cal/gm		1600			
	Ses Volume, cc/gm	•	715	ii mm Morter Projectile:	1	
	mation, cal/gm		400	50% Inert, Velocity, ft. Aluminum Fineness	/ Sec	
	ion, col/gm					
	tonation, cal/gm		1486	500-16 General Purpose Be	mbe:	
Specif	lis Hest: co!/gm/*C					
Li	guid		0.356	Plate Thickness, inches		
8-1	114		0.315	1		
50.	T10		(عز •••	14		
				11/2		
				134		
	ng Rote:					
cm	/sec			Comb Drop Test:		
	n <b>si Conductivity:</b> /sec/cra/*C			17, 2000-16 Semi-Armor-1	liercing Bomb	vs Concrete:
Casti	iciant of Expension:			Max Safe Drop, ft		
	eor, %/*C		•	500-16 General Purpose B	emb vs Cencr	ste:
Vo	lume, %/*C			Height, ft		
M				Trials		
Herdi	ness, Mohs' Scale:			Unaffected		
Yama				Low Order		
	dynes/cm²			High Order		
	b/inch <sup>2</sup>		• • • •	1000) B. General B	and a Con	
-	nsity, gm/cc			100+)-Ib General Purpose (	runna Al Manci	
				Height, ft		
Comp	ressive Strength: Ib/inch <sup>2</sup>			Trials		
				Unoffected		
•	r Pressure:			Low Order		
°c	mm Mercury	<u>°с</u>	mm Mercury	High Order		
20	0.00025	60	0.0188			
30	0.00083	70	0.043 0.098	1		
<u> 4</u> 0	0.0024	80		1		

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### Nitroglycerin (Liquid)

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Fragmentation Trat:	Sheped Charge Effectiveness, TNT = 100:		
90 mm HE, M71 Projectile, Let WC-91: Dena/ty, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth		
Total No. of Fragments: For TNT	Colorless		
For Subject HE , <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	Principal Uses: Propellant ingredient, demoli- tion explosive ingredient, grenade burster ingredient		
Total No. of Fragmonts: For TNT	Method of Looding:		
For Subject HE	Loading Density: gm/cc		
Fregment Velocity: ft/sec At 9 ft At 25½ ft Dersity, gm/cc	Storege: Method With acetone or other desensitizer,		
Blast (Relative to TNT):	generally not stored Hazard Class (Quantity-Distance) Class 9		
Air: Peak Pressure Impulse Energy	Compatibility Group		
Air, Confined: Impulse	Heat of Transition, cal/gm: Transition:		
Under Weter: Peak Pressure Impulse	Liquid> labile 5.2 Labile> stable 28.0 Liquid> stable 33.2 Hydrolysis, \$ Acid:		
Energy Underground: Peak Pressure	1.0 days at 22°C <0.002 5 days at 60°C 0.005		
Impulse Energy	82.1°C KI Test: Minutes 10+		

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#### Mitroglycerin (Liquid)

### Gas Evolved at Atmospheric Pressure, cc:

Sample Wt, gm		1.6
Temperature, °C	65	75
Time, hours	20	+0
Volume of gas, cc	nil	nil
Viscosity: (c)		

°c	Centipoises
10	69.2
20	36.0
40 40	21.0
40	13.6
50	9.4
60	6.8

#### Fregmentation Test:

20 mm HE, Mark 1, Projectile, Total No. of Fragments for:

Nitroglycerin	22
Tetranitromothane	17

### Minimum Propagating Mameter: (d)

<u>\$ Discthylphthalate</u> in NG	Min. Propagating Diameter, inches	lurys in
0 5 10 15 20 22.5 25	(3/16 Cairne) 1/3 1/4 3/4 1 1.55	 1/16 1/8 3/16 1/8 1/2 2/2 2

### Sensitivity to Electrostatic Machange, scales (test condition, unconfined; no value given for confinement); > 12.5

Solubility, grame of nitroglyceria/100 gm (5) of:							
_	ter	<u>A1</u>	<u>cohol</u>	Trichler	ethylene	Carbon Tet	rachloride
°c	ž	°C	ž	<u>°C</u>	4	°c	٤
15 20 50	0.16 0.18 0.25	50 0	37•5 54•0	Ra	22	Rm	2

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#### Nitroglyceri (Liquid)

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	bon Disuli	fide			gm/100	6 <sup>-1</sup> (d),	at 250	C in	
°c		ž			Ether			**	
Ambi	ent	1			Aceton	her:Alco E	nol >	100 ∞	
Soluble in all Proportions in:									
Met	hanol				Phenol				
Ace	tone				Pyridi	ne			
Eth					Xylene				
	yl acetate	•			Nitrob	enzene			
	1 acetate				p-Nitrotoluene				
	hyl nitrat				Liquid DNT				
	yl nitrate	3			Chloro	form			
	roglycol					chloride			
	renitrodia	lycer	ine			promide			
Acetic acid					loroeth				
	zene					roethyle			
Tol	uene				Trimet)	ylenegly	ycol Di	nitrate	
801	ubility in	NG,	of:						
Alc	ohol	D	NT	1	NT	Wa	ter		
°c	£	°c	٤	<u>2°</u>	£	°c	ž		
•	<b>.</b>	~			••				

		-		-			
°c	٤	°c	٤	<u>°°</u> .	ě	°c	2
0 20 50	3.4 5.4	20	<u>?</u> 5	20	30	25	0.06

Preparation:

.

Сн <sub>2</sub> ОН		CH2-0N02	
CHOH	+ 3HNO3	CH -ONO2	+ 3H20
CH2 CH		CH2 - ONO2	

Glycerine is usually nitrated at  $25^{\circ}$ C, or below, by adding it very slowly to a well agitated mixture of nitric and sulfuric acids, e.g., 40/59.5/0.5, nitric acid/sulfuric acid/water, us-ing an acid/glycerine ratio of approximately 6. Agitation of the reaction mixture is accom-pliabed by use of compressed air. A rapid temperature rise, or appearance of red fumes, auto-matically requires dumping of the charge, immediately, into a drowning vessel filled with water. After all the glycerine has been added to the nitrator, agitation and cooling are con-tinued until the temperature drops to about  $15^{\circ}$ C, and the charge is then run into a separator where the NG rises to the top, and is run off to the neutralizer. The nitroglycerin is washed first with water, then with sodium carbonate, and finally with water. The resultant NG when washed with water, produces washings which do not color phenolphthalein, and itself is neutral to liture paper.

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#### Nitroglycerin (Liquid)

#### Origin:

Nitroglycerin was first prepared in 1846 or 1847 by Ascanio Sobrero, an Italian chemist (Nem Acad Torino (2) 10, 195 (1847)). For several years after this discovery, nitroglycerin attracted little interest as an explosive until Alfred Nobel in 1864 patented improvements in its manufacture and method of initiation (British Patent 1813). Nobel gave the name dynamite to mixtures of nitroglycerin and non-explosive absorbents, such as charceal, siliceous earth or Kieselguhr (Dritish Patent 1345 (1867)) Later developments led to gelatine dynamites. annonis dynamites, and so called straight dynamites. The first propellants using nitroglycerin vere called Hallistite (Nobel, British Patent 1471 (1888)) and Cordite (/bel and Devar, British Patents <u>5614</u> and <u>11,664</u> (1889)).

#### Destruction by Chemical Decomposition:

Witroglycarin is decomposed by adding it slowly to 10 times its weight of 18% sodium sulfide (Na<sub>2</sub>S-9H<sub>2</sub>?). Heat is liberated by this reaction; but this is not hazardous if stirring is maintained during the addition of nitroglycerin and continued until solution is complete.

### References: 48

(a) A. E. Blatt. <u>Complication of Data on Organic Explosives</u>, OSRD Report No. 2014, 29 February 1044.

- (b) Ph. Macoum, <u>2 ges Schiess-Sprengstoffw</u>, pp. 181, 229, 267 (27 June 1932).
- (c) Inndolt Bornstein, Physikalisch-Chemische Tabellen, 5th Ed. (1923).

International Critical Tables.

B. T. Fedoroff et al, <u>A Manual for Explosive Laboratories</u>, Vol 1-IV, Lefax Society, Inc., Philadelphia, 1943, 1946.

(d) H. A. Strecker, Initiation, Propagation and Luminosity Studies of Liquid Explosives, OSRD Report No. 5509, 3 December 1945.

(e) Also	see the	followin	g Ficat	inny Ars	enal Tec	hnical I	Reports o	n Nitrog	lycerin:
<u>o</u>	<u>1</u>	2	3	<u>4</u>	ž	6	<u>7</u>	8	2
620 660 800 1020 1150 1210 1410 1620 1680	511 551 701 891 1031 1031 1031 1031 1031 1031 1221 1611 1651 1651 1651 1731 1781 1931 2021 2181 2201	652 672 792 922 1142 1282 1362 1542 1662 1692 1742 1752 1992	233 343 673 903 1023 1443 1643 1863 1993	454 494 1024 1074 1454 1624 1624 1674	1155 1235 1955 2013	1206 1456 1556 1556 1616 1786 1816 1896 2056	817 837 1197 1297 1637 1817 1847	768 1348 1398 1738 1918 2098	69 249 579 709 1349 1359 2119

<sup>49</sup>See footnote 1, page 10,

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	AMCP //06-17/		
Composition:		Molecular Weight: (CH4N402)	104
₩ C 11.5 NH.		Oxygen Belonce:	
c 11.5 NH <sub>2</sub>		CO. %	-31
H 3.9 HN - C		CO %	-15.4
N 53.8 NH		Density: gm/c Crystal	1.72
n 30.8 NO2		Melting Point: "C	2 <b>32</b>
C/H Ratio 0+038		Freezing Point: "C	
Import Sensitivity, 2 Kg Wt:	47	Boiling Point: "C	
Bureau of Mines Apparatus, cm Sumple Wt 20 mg		Refrective Index, ng	
Picatinny Arsenal Apparatus, in.	26 7	na	
Somple Wt, ing	i	n <sub>30</sub>	
Friction Pundulum Test:	(e)	Vecuum Stubility Test:	· 
Steel Shoe	Unsffected	cc/40 Hrs, ot	
Fibe: Shoe	Unaffected	90°C	3.0
		- 100°C	0 ki <b>37</b> − 1
	(e)	120°C	0-44
Schological Scholars		135*C	
Partials 0		150°C	,
Burned 0		200 Grem Bomb Scad Test:	والكابية المصباب بييناني
Unaffected 100		Sand, gm	36.0
Explosion Temperature: °C		Sensitivity to Initiation:	
Seconds, 0.1 (no cop used)		Minimum Detanating Charge, gr	n
		Mercury Fulminate	
5 Decomposes 275	•	Lead Azide	0.20
10		Tetryl	0.10
15 20		Bellistic Morter, % TNT: (a)	104
	· · · · · · · · · · · · · · · · · · ·	Treuzi Test, % TNT: (b)	101
75°C International Heat Test: % Loss in 48 Hrs	0.04	Plate Dant Test: (c)	
		Method	A
100°C Heat Test:		Condition	Pressed
% Loss, 1st 48 Hrs	0.18	Confined	No
% Loss, 2nd 48 Hrs	c.09	Density, gm/cc	1.50
Explosion in 100 Hrs	None	Brisonce, % TNT	95
Flommability Index:		Detenstion Rate: (e) Confinement	
		Condition	
Hygroscopicity: % 30°C, 90% RH	None	Charge Diameter, in.	
		Density, sm/cc	1.55
Velatility:	None	Rate, meters/second	7650

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### Nitroguanidine

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Fregmentation Test:	Sheped Charge Effectiveness, TNT = 100:			
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cone Hole Volume Hole Depth	5		
Yetel No. of Fregments: For TNT	Celer: Colorle	58		
For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc	Principel Uses: Propellant composition ingredies bursting charge ingredient	at,		
Charge Wt, Ib Total No. of Fragmests: For TNT For Subject HE	Mathod of Loading:			
Fregment Velecity: ft/sec	Looding Dansity: gm/cc At 3000 psi	0.95		
At 9 ft At 25½ ft Density, gm/cc	Storage: Method			
Bisst (Relative to TNT):	Hazard Class (Quantity-Distance)	Dry Class 9		
Air: Peck Pressure	Campatibility Group	Group I		
Impulse Energy	Exudation Solubility, gm/100 gm (\$), in:			
Air, Confined: Impulse	v <sub>c</sub> Water 25 100	0.44		
Under Weter: Peak Pressure Impulse	1.0 N Potassium       Hydroxide     25       40% Sulfuric Acid     0       25	1.1 3.4+ 8.0+		
Energy Undorground:	* gm/100 cc solution Booster Sensitivity Test:	(d)		
Pecik Pressure Impulse Energy	Condition Tetryl, gm Wax, in. for 50% Detonation Density, gm/cc	Pressed 100 0.67 1.41		
	Heat of: Combustion, cal/gm Explosion, cal/gm Gas Volume, cc/gm Formation, cal/gm	1995 721 1077 227		

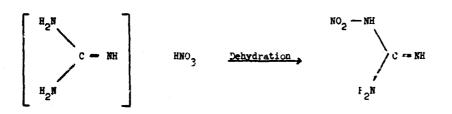
#### Nitroguanidine

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Preparation:

(Chemistry of Powder and Explosives, Davis)



Four hund ed gas of dry guanidine nitrate is added in small portions to 500 cc concentrated sulfuric acid at  $10^{\circ}$ C, or below. As soon as all crystals have disappeared the milky solution is poured into 3 liters of ice-water, and allowed to stand until crystallization is complete. The product is filtered, rinsed with water, and recrystallized from about 4 liters of boiling water, yield about 90%.

#### Origin:

Ritroguanidine was first prepared in 1877 by Jousselin, but it was 1900 before it found use in propellant compositions. During World War I, nitroguanidine was used by the Germans as an ingredient of bursting charge explosives.

#### Destruction by Chemical Decomposition:

Nitroguanidine is decomposed by dissolving in 15 times its weight of 45% sulfuric acid at room temperature and warming the solution until gas is evolved. Hesting is continued for one-half hour.

### References: 49

(a) L. C. Smith and E. G. Fyster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) Canadian Report, CE-12, 1 May-15 August 1941.

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of ROX/Wax Mixtures as a Substitute for Twtryl in Boosters</u>, NOL Memo 10, 303, 15 June 1949.

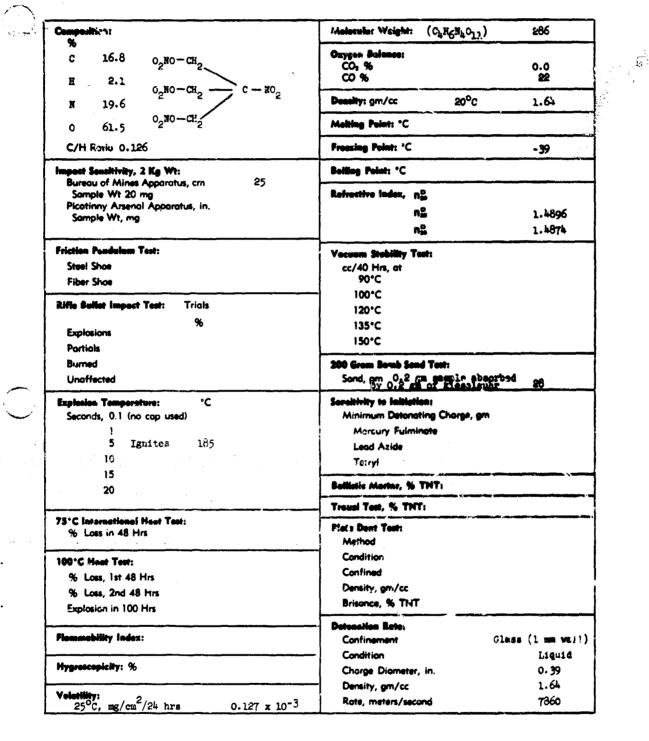
(e) Departments of the Army and the Air Force TM 9-1910/TO 11A-1-34, Military Explosives, April 19,,.

<sup>49</sup>See footnote 1, page 10,

AMCP 706-177 Mitroguenidine (it) Also see the following Picatinny Arsenal Technical Reports on Nitroguanidine: <u>3</u> 1183 1423 2193 2 1262 1392 2142 <u>6</u> I 907 2177 8 9 1 2 1391 2181 2201 1336 758 1439 1749 1490

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### Nitroisobutyiglycerol Trinitrate (NIBTN) Liguid

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#### Nitroisobutylglycerol Trinitrate (NIBTR) Liquid

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Freguesatulion Test:	Shaped Charge Bifeativence, TNT = 100;				
98 km HE, M71 Projectile, Let WC-91: Osneity, gm/cc Charge Wt, Ib	Sicas Cones Suesi Cones Hole Volume Hole Depth				
Total No. of Programmes: For TNT	Celer: Yellow oil				
Fa. Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib	Principal Usas: Gelatinizing agent for nitrocellulose				
Total No. of Fragmants: For TNT For Subject HE	Method of Looding:				
Fregment Velocity: ft/sec	Looding Dontity: gm/cc				
At 9 ft At 25½ ft Density, gm/cc	Storoge: Method Liquid				
Blast (Relative to TRT);	Hazord Class (Quantity-Distance)				
Aiz: Peak Pressure Impulse	Compotibility Group Exudation				
Energy Air, Confined: Impulse Under Water:	Solubility: Soluble in methyl and ethyl sloonols, ace- tone, ether, ethylenedichloride, chloroform and benzene.				
Peak Pressure Impulse Energy	Insoluble in meter carbon disulphide, and petroleum ether. Toxicity:				
Underground: Paak Pressure Impaise Energy	Slight, decidedly less 200 nitroglycerin. <u>Gelatini_ing Action:</u> Slight on nitrocellulose. <u>82.2°C KI fest:</u> Mir.tes 2				

#### Nitroisobutylglycerol Trinitrate (NIBTN) Liquid

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#### Preparation:

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A total of 675 gm 37% formalin is added to 150 gm nitromethane containing 2 gm potassium onrobusts hand-hydrate. The first 200 gm formalin is added slowly, keeping the temperature below 30°C, and then the heat of reaction is allowed to raise the temperature to 80°C, and the mixture then heated two hours at 90°C. The reaction mixture is then concentrated at reduced reast we and diluted, and this process repeated several times to remove formaldehyde. After the sinal concentration the cooled mixture is filtered and the crystalline product recrystallised from alcohol and then several times from ether and dried.

The nitrated product is then obtained by nitrating 50 gm nitroisobutylglycerol with 300 gm mixed acid (60/36/2, sulfuric acid/nitric acid/water) below 15°C for 1.5 hours.

#### Origin:

This explosive (also called Trimethylolnitromethane Trinitrate, Mitroisobutanetriol Trinitrate, Mitroisobutylglycerin Trinitrate and incorrectly but widely used Mitroisobutylglycerol Trinitrate) was first described in 1912 by Hofvinner (Z ges Schiess - Sprengstoffv 7, 43 (1912). Hofvinner prepared the compound by the condensation of 3 moles of formaldehyde with 1 mole of nitromethane in the presence of pctassium bicarbonate, the subsequent nitration of the product. The explosive can now be produced from coke, air, and natural gas.

## References: 50

(a) H. A. Aaronson, Study of Explosive & Derived from Nitroparaffins, PATR No. 1125, 24 October 1941.

- (b) M. Aubry, Mfm poudr, 25, 197-204 (1932-33); CA 27, 4083 (1933).
- (c) A. Stettbacher, Mitrucellulose 5, 159-62, 181-4, 203-6 (1934); CA 29, 1250 (1935).
- (d) W. de C. Crater, U.S. Patent 2,112,749 (March 1938); UA 32, 3964 (1938).

(e) H. J. Hibshman, E. H. Pierson, and H. B. Haas, Ind Eng Chem 32, 427-9 (1940); (A 34, 3235 (1940).

(f) A. Stettbacher, Z ges Schiess Sprengstoffv 37, 62-4 (1942); CA 38, 255 (1944).

<sup>50</sup>See footnote 1, page 10.

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### Mitrosterch Demolition Explosite (NSX)

Controlition:		Molocular Wilght:	<b>3</b> 25	
% Nitrostarch (12.50% N)	49	Oxygen Belence:		•
Barium Nitrate	40	CO. %	-19	1
Mononi tronsph tha lene	7	CO %	8	
Paranitroaniline	3	Density: gm/cc		
011	1	Melting Point: *C	<u> </u>	
C/H Ratio		Freezing Point: 'C		
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	21	Beiling Point: 'C		
Sample Wt 20 mg	8	Refrective Index, no		
Picatinny Arsenal Apparatus, in. Sample Wt, mg	0	. n <sup>p</sup>		1
Sumple VVI, mg		nS		
Friction Pendulum Test:		Vacuum Stability Test:		
Steel Shoe Crackles,	snaps	cc/40 Hrs, ot	•	.
Fiber Shoe Unaffected	l	\$0°C		
		– 100°C	11+	
Rifle Bellet Impact Test: 10 Trials 8	Trials*	120°C		
Suplations 00	\$ 0	135°C		
Explosions 97	-	150°C		
Partials 0	13			{
Burned O	0	200 Gram Bomb Send Test:	<b>••</b> -	
Unoffected 10 *Packed in paper	87	Sand, gm	39.5	· ·
Explosion Teraperature: "C		Sensitivity to Initiation:		· !
Seconds, 0.1 (no cop used)		Minimum Detonating Charge, gm		
1		Mercury Fulminate	0.26	!
5 Decomposes 195		Leod Azide		
16		Tetryl		
15				
20		Bellistic Morter, % TNT: (8)	<del></del>	
75°C International Hast Tast:		Trougi Test, % TNT:		
	0.2	Plote Dont Tost:		
		Method		
100°C Heat Test:		Condition		
	0.3	Confined		
•	0.3	Density, gm/cc		
Explosion in 100 Hrs	None	Brisance, % TNT		
		- Detenation Rate:		
Flemmebility Index:		Confinement		
		- Condition		
Hygrescepicity: % 30 <sup>°</sup> C, 90% RH	2.1	Charge Diameter, in		
	·····	- Density, gm/cc		
Volatility:				

### Nitrostarch Demolition Explosive (NSX)

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- Willy

Fragmontation Test:	Shoped Charge Effectiveness, TNT = 100:
99 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, Ib Total No. of Fragments: For TNT For Subject HE 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib	Gloss Cones Steel Cones Hole Volume Hole Depth Color: Principal Uses: Demolition, bursting charges and priming compositions
Total No. of Fragmants: For TNT For Subject HE	Method of Looding: Hand tamped
regment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc	Leading Density: gm/cc Apparent 0.92 Storege:
Blast (Relative to TNT):	Method Dry Hazard Class (Quantity-Distance) Class Compatibility Group Group
Air: Peok Pressure Impuise Energy	Esurfation None
Air, Confined: Impulse Under Weter: Peak Pressure Impulse Energy	120°C Heat Test:Salmon Fink70Red Fumes255Emplodes256
Underground: Peak Pressure impulse Energy	

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**C** 

Nitrostarch Femolition Explosive (NSX)

### Freparation: (b)

The nitration of starch proceeds with the formation of hexanitro starch according to the following equation:

 $2c_6H_{10}O_5 + 6HNO_3 \rightarrow c_{12}H_{11}O_4(ONO_2)_6 + 6H_2O$ 

Tapicos starch is considured the best for nitration purposes, although other starches give iairly stable products. The starch, pretreated to remove oils, fats and water soluble impurities, is dried and screened. Feeding of the dried starch into stainless steel mitrators containing mixed acid (62%-63% HNO<sub>2</sub> and 37%-30% H<sub>2</sub>SO<sub>6</sub>) is done slowly with constant agitation of the mixture. The best evolved must be controlled by cooling coils. The nitrated starch is separated from the spent acid, washed with a large amount of water and centrifuged. Final drying is on trays heated to  $35^{\circ}-h0^{\circ}$ C with air. This product is so sensitive even a static discharge might cause explosion.

Mitrostarch demolition explosives contain a high percentage of nitrostarch, an oxidizing agent, mineral oil, a stabilizer and/or other ingredients.

#### Origin:

Ritrostarch was first prepared in 1833 by Branconnot, who called it xyloidine (Ann chim phys [2] 52, 290 (1833)). T. J. Pelouse studied xyloidine further and reported its explosive properties (Compt rend 7, 713 (1836). It found military use in the United States during World Wars I and II as blasting explosives and as an ingredient of bursting charges and priming compositions.

#### References: 51

(a) W. R. Tomlinson, Jr., <u>Physical and Explosive Properties of Military Explosives</u>, PATR No. 1372, 29 November 1943.

(b) G. D. Clift and B. T. Fedoroff, <u>A Manual for Explosives Laboratories</u>, Vol I, Lefax Society, Inc., Philadelphia (1942).

(c) Also see the following Picatinny Arsenal Technical Reports on Nitrostarch Explosives:

1	2	<u>4</u>	I	<u>8</u>	2
1611	782 2022	103 <sup>4</sup>	1117	8 <b>3</b> 8	1269

<sup>51</sup>See footnote 1, page 10.

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Octol,	70/30
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		فتحصر فسير المقاد المستكر مستجها الشيرية المحمد والمتحد والمتحد	والمستقد والمستقد والمستقد المستقدة المستقدة
Composition: %		Moleculer Weight:	265
HNOX	70	Oxygen Belence:	
BRA		CO, %	- 38 - 7 - 5
INT	30		
		Density: gm/cc Cast	1.80
		Molting Point: "C	
C/H Rotio		Freezing Point: *C	
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm		Boiling Point: *C	
Sample Wt 20 mg		Refrective Index, ng	
P cotinny Arsenal Apparatus, in. Sample Wt, mg	18 26	n <u>e</u>	
Schulen vvi, mg	20	n 🕫	
Friction Pondulum Test:		Vacuum Stability Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	
Rifle Bullet Impact Test: Trials			
%		120.0	0.37
Explosions		135°C	
Partials		150°C	
Burned		200 Grem Bemb Send Test:	
Unaffected		Sond, gm Exploratory	58.4
Explacion Temperature:	°c	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, gm	
] 5 Flames erratical:	Ly 335	Mercury Fulminata	
•	<b>L</b> 337	Lead Azide	0.30
10 15		Tetryi	****
20		Ballistic Mortor, % TNT:	115
		Trauzi Test, % TNT:	
75°C International Hast Tust: % Loss in 48 Hrs		Plate Dent Test: Method	
	······································	Condition	
100°C Heat Tent:		Confined	
96 Loss, 1st 48 Hrs		Density, gm/cc	
% Loss, 2nd 48 Hrs Explosion in 100 Hrs		Brisance, % TNT	
Flammability Index:		Detenation Rate: Confinement	None
		Condition	Cast
Hygrescepicity: %		Charge Diameter, in:	1.0
		Density, gm/cc	1.80
Velatility:		Rate, meters/second	8377
		Note, meters/second	1160

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## <u>Octol, 70/30</u>

Beester Sansitivity Test:		Decomposition Equation:	}
Condition	۰.	Oxygen, atoms/sec	
Tetryi, gm		(Z/sec) Heat, kilocolorie/mole	
Wax, in. for 50% Detonation		(ΔH, kcol/mol)	
Wax, gm		Temperature Ronge, °C	Ì
Density, gm/cc		Phase	
Nest of:	2722	Armer Plate Impact Test:	
Combustion, cal/gm	1074		
Explosion, coi/gm	847	60 mm Marter Projectile:	
Gas Volume, cc/gm	•	50% Inert, Velocity, ft/sec	
Formation, col/gm		Aluminum Fineness	
Fusion, cal/gm		500-Ib Ganeral Purpose Bomhs:	
Specific Heat: C (/gm/°C	· · ·		1
-point man c ( gut C		Plate Thickness, inches	
		1	
		1%	
		11/2	
		13/	
Gerning Rote: cm/sec			_
		Bomb Drop 'Test:	ł
Thormal Sonductivity:			10th
cal/sec/cm/*C		77, 2000-lb Semi-Armon Piercing Bomb vs Concrete:	
Coefficient of Expansion:		Max Safe Drop, ft	
Linear, %/*C		500-16 General Purpose Bomb vs Concrete:	
		Juile Concrete Parpose Danie VS Concrete.	
Volume, %/*C		Height, ft	
		- Trials	
Hardness, Moha' Scale:		Unaffected	
Young's Modulus:	· · · · · · · · · · · · · · · · · · ·	Low Order	1
E', dynes/cm²		High Order	
E, ib/inch <sup>2</sup>		1000 K. Connect Russian Barrish up Connector	
Density, gm/cc		1000-16 General Purpose Bomb vs Concrete:	
		Height, ft	
Compressive Strength; Ib/inch <sup>2</sup>	1510	Trials	
	See below	Unaffected	
Vapor Prossure:		Low Order	1
*C mm Mercury		High Order	
Compressive Strength: 1b/inch <sup>2</sup>	*		
Average (10 tests)	1510	Ultimate Deformation: %	1
High Low	1740 1330		
	<b>~</b> €€±	Average (10 tests)         2.26           High         2.58           Low         1.97	
			_1

\*Test specimen 1/2" x 1/2' cylinder (approximately 3 gm) pressed at 3 tons (6.000 lb) total load or 30,000 psi with a 2 minute time of dwell.

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Octol, 70/30

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· · · · · · · · · · · · · · · · · · ·		_
Fregmentation Test:	Shaped Charge Effectiveness, TNT == 160:	
99) man HE, M71 Projectili, Ler WC-91: Density, gm/cc Chorge Wt, Ib	Glass Cones Steei Cones Hole Volume Hole Dopth	
<b>Total No. of Fragments:</b> For TNT For Subject HE	Color:	Buff
3 Inch: HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Chorge Wt, Ib	Principal Uses: HE projectile and bomb	filler
Tatal No. of Fragmaniu: For TNT For Subject HE	Method of Loading:	Cast
•	Looding Density: gm/cc	1.80
Fregment Velocity: It/sec At 9 ft At 25½ ft Density, gm/cc	Sterage: Method	Dry
Blast (Relative to THT):	Hazarri Class (Quantity-Distance)	class 9
Air: Peak Pressure Impulse Energy	Compatibility Group Exudation	Group I
Air, Confined: Imputse Under Weter: Peak Pressure Imputse	Work to Produce Rupture: ft-lb/inch <sup>3</sup> Average (10 tests) High Low Efflux Viscosity, Saybolt Seconds:	* 1.55 1.87 1.10 5 9
Energy Underground: Pook Pressure Impulse Energy		
	*Test specimen 1/2" x 1/2" cylinder (a mately 3 gm) pressed at 3 tons (6,000 total load or 30,000 psi with a 2 min time of dwell.	) 1b) —

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### Octol, 70/30

#### Effect of Altitude. Charge Diameter and Degree of Confinement on Detonation Velocity\* (Reference b)

	1	One-Inch Column		Two-Inch Column	
Explosive	Simulated Altitude,	Confined	Unconfined	Confined	Unconfined
· · · · · · · · · · · · · · · · · · ·	Feet	m/ 8	m/ 8	m/s	E/ 8
70/30, RUX/INT; density, gm/cc 1.62	Ground	7900	8100	7660	8030
	30,000	8020	8120	7900(4)	7800
	60,000	8040	8140	8010	7950
	90,000	8060	7980	8010	7710
Average		8005	8085	7895	7873
70/30, HMX/TNT;	Ground	7960	7900(4)	7870	7640(4)
density, gm/cc 1.61	30,000	8050	8060	7930	7710
	60,000	8020	79 <b>30</b>	7890	7650
	90,000	7950	8000	7940	7650
Average		7995	7973	7908	7663

\*70/30 Octol confined charge in 1/4" steel tube, AISI 1015 seemless, 1" diameter 18" long, and 2" diameter 7" long. All means were determined from sets of five values unless otherwise indicated by (). A 26 gm tetry booster was used to initiate each charge.

		Simulated Altitude, Feet			
Explosive	Charge Diameter,	Ground	30,000	60,000	90,000
	Inches	m/ 6	m/s	¤/s	. m/s
70/30, RDX/TNT	1	3415	3672	3666	3685
	2	4647	5192	5 <b>23</b> C	6011
70/30, HMX/11NT	1	3366	3680	4014	3617
	2	4703	5464	6089	6111

### Average Fragment Velocities at Various Altitudes\* (g)

\*Outside diameter 2.54"; inside diameter 2.04"; length 7".

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Tensile Strength:*		
	lb/inch <sup>2</sup> 169	
Average (8 tests)	169	
High	204	
Lov	128	

"Test specimen as per Picatinny Arsenal sketch XL-076B, at 21°C.

#### Noculus of Elasticity:\*

· · ·	1b/inch <sup>2</sup> 73,200
Average (10 tests)	73,200
High	79, 300
Tow	63.00

Low 63,00 \*Test specimen 1/2" x 1/2" cylinder (approximately 3 gm) pressed at 3 tons (6,000 lb) total load or 30,000 ps; with a 2 minute time of dwell.

### Setback Sensitivity Test: ( )

Critica? Prassure	92,000 psi*
Density, ga/ce	1.72

Density, pa/cc 1.72 \*Pressure below which no initiation is obtained and above which an increasing percentage of initiations can be expected as the setback pressure increases.

## Pit Fragmentation Test:

105 mm NL HE Projectile;

Weight Group, grains	No. of Fragments
1/2 - 2	1297
2 - 5	665
5 - 10	497
10 - 25	661
25 - 50	472
50 - 75	247
75 - 150	322
150 - 750	295
750 - 2500	1?
Total Number	4467

### AMCP 706-177

## Octol, 75/25

	UE to.	<b>()</b> ( <b>)</b> ( <b>2</b> )	,
Competition;		Molecular Weight:	276
96 180X	75	Oxygen Belence:	
,		CO- %	-6.3
TNT	25	Density: gm/cc Car	1.81
		Malting Point: °C	
C/H Ratio		Freezing Point: "C	
impect Sensitivity, 2 Kg Wt:		Beiting Point: *C	
Bureau of Mines Apparatus, cm			
Sample Wt 20 mg Picatinr.y Arsenal Apparatus, in.	17	Refrective Index, no	
Sample Wi, mg	25	nä	
		n	
Friction Pendulum Test:		Vacuum Stability Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unsffected	90°C	
2/fie Bullet Impect Test: 10Trials 9			
3/16"_Steel	1/8" AL	120°C	0.39
Explasions 70	70	135°C	1
Portials		150°C	
Burned		200 Grem Bemb Send Test:	
Unaffected 30	30	Sond, gm Exploratory	62.1
Explosion Temperature:	°C.	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)	•••	Minimum Detonating Charge, gm	
1		Mercury Fulminate	
5 Flames erratically	r 350	Lead Aside	0-30
10		Tetryi	
i 5 20		Ballistic Morter, % TNT:	116
		Truest Teet, % TNT:	
75°C International Heat Test: % Loss in 48 Hrs		Plate Dent Test:	
		Method	l
100°C Heet Test:		Condition	
% Loss, 1st 48 Hrs		Confined	
% Loss, 2nd 48 Hrs		Density, gm/cc	
Explosion in 100 Hrs		Brisance, % TNT	
		- Detenation Rate:	
Planmability Index:		Confinement	None
		Condition	Cast
Hygrassopicity: %		Charge Diameter, in.	1.0
		- Density, gm/cc	1.81
Velatility:		Rate, meters/second	8643

### <u>Octol, 75/25</u>

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Bosster Sensitivity Test:	Decomposition Equation:
Condition	Oxygen, atoms/sec (Z/sec)
Tetryl, gm	Heat, kilocalorie/mole
Wax, in. for 50% Detonation	(AH, kcol/mol)
Wax, gm	Temperature Range, *C
Density, gm/cc	Phase
Vient of:	
	676 Armer Plate Impact Test:
Explosion, col/gm 11	131
	830 50% inert Velacity, ft/sec
Formation, cal/gm	Aluminum Fineness
	9,4*
Fusion, col/gm 25 *Calculated for 76.9% HMX, 23.1% INT.	
$\begin{array}{c} -80^{\circ} t_{0} +80^{\circ} c \\ 33^{\circ} t_{0} +74^{\circ} c \\ \end{array}$	- 200 Plate Thickness, inches - 240
$33^{\circ}$ to $74^{\circ}C$ 0.	.245
	.323
**Determined for 76.9% HMX, 23.1% TNT.	11/4
	11/2
Burning Rate:	
cm/sec	Bomb Drop Test:
Thermal Conductivity:	T7, 2000-16 Semi-Armer-Piercing Semb vs Concrete:
co:/sec/cm/*C	
	Max Safe Drop, ft
Coefficient of Expension:	
Linear, %/*C	500-ib General Purpose Bomb vs Controle:
Volume 06 /20	
Volume, %/*C	Height, ft
	Triois
Herdness, Mohs' Scole:	Unaffected
	Low Order
Yeung's Medulus:	High Order
E', dynes/cm²	
E, Ib/inch <sup>=</sup>	1000-16 General Purpose Bomb vs Concrete:
Density, gm/cc	ч
	Height, ft
Compressive Strength: Ib/inch <sup>2</sup>	340 Triols
See	below Unoffected
Vapor Pressure: *C mm Mercury	
	High Order
	***
	340 Ultimate Deformation: %
	560 Average (10 tests) 2.43 040 High 2.69
	040 High 2.59 Low 2.04

\*\*\*Test specimen 1/2" x 1/2" cylinder (approximately 3 gm) pressed at 3 tons (6,000 lb) total load or 30,000 psi with a 2 minute time of dwell.

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Octol, 75/25

Fragmenteflee Test:	Shaped Charge Effectiveness, TNT = 109:	
90 mm HE, M71 Projectile, Lot WC-91:	Glass Cones Steel Cones	
Density, gm/cc	Hole Volume	
Chorge Wt, Ib	Hole Depth	
Total No. of Fragments:	Color:	Buff
For TNT		
For Subject HE		
	rincipal Uses: HE projectile and bomb	ntier
3 inch HE, M42A1 Projectile, Let KC-5:		
Density, gm/cc		
Chorge Wt, Ib		
Tatal No. of Fragments:		
For TNT	Method of Loading:	Cast
For Subject HE		
	Leading Density: gm/cc	1.81
Pregment Velocity: ft/sec		
At 9 ft		
At 251/2 ft	Storage:	
Density, gm/cc	Method	Dry
Blast (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 9
Aire	Compatibility Group	Group I
Peak Pressure	Exudation	
Impulse		
Energy		
Air, Continué:	Work to Produce Rupture: ft-lb/inch <sup>3</sup>	. *
Impulse	Average (10 tests)	1.31
	High	1.57
Under Water: Peak Pressure	Low	1.07
imputse	Efflux Viscosity, Saybolt Seconds:	9.0
Energy		
Underground: Poak Pressure		
Impulse		
Energy		
	*Test specimen 1/2" x 1/2" cylinder (4 mately 3 gm) pressed at 3 tons (6,000 total load or 30,000 psi with a 2 min time of dwell.	<b>5</b> 1b)
	h ·	

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Octo1, 75/25

(a) Frequent Velocity Test: M26 Hand Grenade:

Explosive	Average Fragment Velocity, ft/sec over 1st 6 feet
Composition B	4948
75/25 Cyclotol	4908
75/25 Octol	5124

Tensile\_Strength:\*

	lb/inch <sup>2</sup>
Average (10 tests)	266
High	330
LOW	226

\*Test specimen as per Picatinuy Arsenal sketch XL-076B, at 21°C.

(a)

#### Modulus of Elasticity:\*

		1b/inch <sup>2</sup>
Average	(10 tests)	62,100
High		75,900
Low		45,200

"Test specimen 1/2" x 1/2" cylinder (approximately 3 gm) pressed at 3 tons (6,000 lb) total 1(3d or 30,000 psi with a 2 minute time of dwell.

Setback Sensitivity Tetz: (a) Critical Pressure 76,000 pai\* Runsity, ga/cc 1.80 Freesence below which no initiation 10 obtained and above which an increasing percentage of initiations can be expected as the setback pressure increases.

## Pit Fragmentation Test:

105 mm ML HE Projectile: Weight Group, grains 1/2 - 2 2 - 5 5 - 10 10 - 25 25 - 50 50 - 75 75 - 150 150 - 750 756 - 2500 No. of Fregments 1611 777 535 719 480 246 339 293 8 5008 Total Number

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## AMCP 706-177

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### Octol, 70/30; Octol, 75/25

#### Preparation:

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Water-wet HNX is added slowly to molten TNT in a steam-jacketed kettle at a temperature of 100°C. The mixture is heated and stirred until all moisture is evaporated. The composition is cooled to a satisfactory pouring temperature and cast directly into ammunition components or prepared in the form of chips to be stored for later use.

## References: 52

(a) 1st Indorsement from Chief, Explosives Development Section, to Chief, Explosives Research Section, Picatinny Arsenal, dated 12 May 1958. Subject: "Properties of Octols and HTA-3."

(b) A. W. O'Brien, Jr., C. W. Plummer, R. P. Woodburn and V. Philipchuk, <u>Detonation Veloci-</u> ty Determinations and Fragment Velocity Determinations of Veried Explosive Systems and Conditions, Mational Morthern Corporation Final Summary Report NNC-F-13, February 1958 (Contract DAI-19-020-501-ORD-(P)-58).

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52See footnote 1, page 10.

PB-RDX

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Sempention: %		Molocular Weight:	245
RDX	90	Oxygen Selence:	
		CO: %	-62
Polystyrene (unmodified)	8.5		-18
Dioctylphthalate	1.5	Density: gm/cc Unpressed Pellet pressed at 30.000 psi	0.81
		Molting Point: "C	
C/H Rotio		Freezing Point: "C	
Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	Unpressed 28	Boiling Point: "C	
Somple Wt 20 mg	15	Rafrective Index, Na	
Picatinny Arsenal Apparatus, in. Sample Wt, mg	15 20	n <sub>22</sub>	
		n <b>o</b>	
Friction Pondulum Test:		Vocuum Stability Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	
		- 100°C	
Rifle Bullet Impact Test: 10 Trials *		120°C	0.41
% Explosions 1.0		135°C	
Partials 90		150°C	
Burned 0			
•••••••		200 Grem Bomb Sand Test:	
Unoffected 0		Sond, gm	
Explesion Temperature: *C		Sensitivity to Initiation:	
Seconds, 0.1 (no cop used)		Minimum Detonating Charge, gm	
1		Mercury Fulminate	
<b>5 Smokes</b> 275		Leod Azide	
10		Tetryl	
15		Ballinia Manhar & Watt	
20		Bellistic Morter, % TNT:	
75 °C International Heat Test:		_ Treuzi Teet, % TNT:	
% Loss in 48 : Ins		Plate Dent Test: Method	
100°C Heat Test:		Condition	
% Loss, 1st 48 Hrs	0.00	Confined	
% Loss, 2nd 48 Hrs	0.00	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TNT	
Flammability Index:		- Detenstion Rate: Confine.nent	
· • ·		- Condition	
Hygroscopicity: %		Charge Diameter, in.	
* Test procedure described in	PATE No. 2247	Density, gm/cc	
May 1956.		Rate, meters/second	

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PB-RDX

Bassier Sensitivity Test: Condition	Decomposition Equation: Oxygen, atoms/sec	]
Tetryl, gm	(Z/sec)	
Wax, in. for 50% Detonation	Heat, kilocalorie/mole	
Wax, gm	(∆H, kcal/mol) Temperature Range, °C	
Density, gm/cc	Phase	
	Fridse	
Next of: Combustion, col/gm 3027	Armor Plate Impact Test:	
Explosion, col/gm 983		
Gas Volume, cc/gm	60 mm Morter Projectile:	
Formation, cal/gm	50% Inert, Velocity, ft/sec	
	Aluminum Fineness	
Fusion, cal/gm	500-b Ganerai Purpeso Bembs:	
Specific Heat: cal/gm/*C		1
	Plate Thickness, inches	
	1	
	14	
	11/2	
	172	
Berning Rate:	4 <b>1 1 1 1</b>	1
cm/sec		1
	Bomb Drep Text:	
Tharmal Conductivity:		
col/sec/cm/°C	17, 2000-16 Semi-Armer-Piercing Bemb vs Concrete:	
	Max Sate Drop, ft	
Coufficient of Expansion: Linear, %/*C		
	500-ib General Purpose Brink vs Concrete:	
Volume, %/°C		
	Height, fr	1
Hardness, Maha' Scale:	Trials	
	Unaffected	
Young's Modulus: See below	Low Order	
E', dynes, 'cm²	High Order	
E, Ib/inch <sup>2</sup>		
Density, gm/cc	1000-lb General Purpose Bomb vs Concrete:	
Compressive Strength: Ib/inch <sup>2</sup> 2403 2149	Height, ft	
Percent 8.9 13.1	Trials	1
	Uriaffected	1
Vapor Pressure:	Low Order	
°C mm Mercury	High Order	l
Young's Modulus: * (a) Temperature		
E, 1b/irch <sup>2</sup> (avg of 5) Ambient 95°C 39,953 34,831		1
Density, gm/cc 1.60 1.57		
		ĺ

\*Pellets (Lot OAC-596-55) 0.750 inch diameter by 0.750 inch long, pressed at 30.000 ps: with 30-second dwell.

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	PB-RDX		AMCP 706-177
Fregmentation Test:	Shaped Chorge	Effectiveness, TNT =	= 100:
90 mm HE, M71 Projectile, Let WC-91:		Glass Cones Ste	el Cones
Density, gm/cc	Hole Volume	•	
Charge Wt, Ib	Hole Depth		
Tetal No. of Fragmants:	Celer:		
For TNT	Comit		White
For Subject HE	Bringh of Jings	High wechanical	etwo ath
3 inch HE, M42A1 Projectile, Let KC-5:	rincipal data:	explosive	r surengun
Density, gm/cc			
Charge Wt, Ib			
Total No. of Fragments:		•	
For TNT	Method of Loo	me:	Pressed
For Subject HE			
	Leading Density	- And or	psi x 10 <sup>3</sup>
regment Velocity: ft/sec	0 10	20 30 1.59 1.62	
At 9 ft		1.77 1.02	
At 251/3 ft	Storage:		
Density, gm/cc	Method		Dry
linet (Relative to TNT):	Hazard Class	(Quantity-Distance)	Class 9
Air:	Compatibility	6	Group I
Peak Pressure			
Impulse	Exudation		None
Energy			
Air, Confined: Impulse	Rockwell Has 1/2 inch die	rdness, "R" Scale Ameter Penetrator	: (a) 5, 60 Kg Lond:
Under Water:	Pellet	Specific	
Peak Pressure	<u>Ne.*</u>	Grevity	Hardness
Impulsa	1	1.624	84
Energy	2	1.623	<b>90</b>
	3	1.611 1.600	84 80
Underground: Peak Pressure	5	1.590	75
Impulse	6 7	1.571 1.548	73 62
Energy	8	1.524	49
- •7			
	*Pellets (Lot	HOL-F-93) were	1-1/2 inches

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\*\*\*\*CP 706-177

				Special			(a)
Pellets	Gap 0.250	(Distand 0.300	0.350	Base of ( 0.400	2ap to Pe 0.450	<u>ellet), I</u>	
PB-RDX with Pellet Density 1.55 gm/cc					0	0.500	0.75
Ro. of Trials	-	8	5	6	2	1	1
Average Depth of Plate Indentation, inches **	0.082	J•090	0.087	0.080	0.080	_	
No. of Failures	o	1	3	4	1	1	1
PB-RDX with Pellet De3ity 1.60 gm/cc							
No. of Trials	- 3	8	9	14	3	5	2
Average Depth of Plate Indentation, inches **	0.090	0.089	0.087	<b>).</b>	0.087	0.075	
No. of Failures	0	0	2	3	2	3	2
98/2 PDK/Stearic Acid With Pellet Density 1.63 gm/cc							<u> </u>
No. of 'frials	- 5	3	5	>	5	5	5
Average Depth of Plate Indentation, inches **	0.109	0.096	0.095	0.092	0.097	0.087	-
No. of Failures	0	1	o	3	4	4	5

PB-RDX

Performance of PB-RDX as Booster: (b, d)

Ten 2.75 inch HEAT ML Rocket Heads were unaffected in performance by storage at 71°C for 28 days. Thus, FB-RDX was not desensitized by contact with TNT-bearing explosives. Tetryl, similarly used, becomes desensitized when stored in bursting charges at elevated temperatures.

In addition, 108 modified M307Al 57 mm projectiles were fired for performance against armor. Each round contained a PB-RDX booster pellet. There was no evidence in these firings that the projectiles were inadequately boostered.

#### PB-RDX

AMCP 706-177

#### Preparation:

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The purchase description sheet for polystyrene-bonded RDX (X-PA-PD-1.088, 25 October 1956) requires that the PB-RDX shall be a mixture of RDX, coated and surrounded by a homogeneous mixture of polystyrene and dioctylpathalate. The specified percentage of RDX shall consist of a mixture of 75% Type B, Class A RDX and 25% Type B, Class E RDX. The granulation of the unpressed composition shall be as follows:

Through U. S. Standard Sieve No.	Minimum 🕉	Maxi	mum %
6	100	**	
12	60		:
20		2	•
35		0	

Two methods have been reported for the preparation of PB-RDX (Reference: Los Alamos Scientific Laboratory, Contract W-7405-Eng 36 with U.S. Atomic Energy Commission, Report No. IA-1448). The earlier method employed a Baker-Perkins type mixer to blend the components. This procedure gave a product with good pressing characteristics. However, the molding composition was nonuniform in granulation and tended to be dusty. The slurry method of PB-RDX granulated by the slurry method exhibited satisfactory drying, handing and pressing characteristics.

The final procedure incorporating the better features found from the study of such variables as solvents, solvent/plastic ratios, lacquer addition and temperature, agitation, RDX particle size distribution, dispersants and rosin additive, was as follows (Reference c):

Forty-two and five-tenths grams (42.5 gm) of polystyrene and 8 cc dioctylphthelate were dissolved in 200 cc toluene in a lacquer dissolver. Steam was introduced into the jacket until the temperature reached  $65^{\circ}$ C. The lacquer was agitated constantly until it was ready to be added to the granulator. This lacquer contained a 1:4 ratio of plastic-plasticizer to toluene.

Four hundred and fifty grams (450 gm) of RDX and 4500 grams of  $H_20$  (ratio 1:10) were added to the grenulator. The agitator was set for 400 rpm and the temperature was raised to 75°C by introducing steam into the jacket. The temperature differential between the lacquer solution and the RDX/water slurry was 5° to 10°C.

The lacquer solution was poured through the clarging funnel into the granulator. As soon as the lacquer was added, a solution of gelatin in water was added, and the mixture was agitated until the lacquer was well dispersed in the RDX slurry (approximately 5 minutes). Granulation took place at this point. Steam was introduced again into the jacket to distill the solvent until the temperature reached 98°C. Cooling water was then run into the jacket to cool the batch to  $40^{\circ}$ C. The coated material from the granulator was collected on a Buchner funnel and dried in a tray at 70°C for 24 hours. Temperatures below 70°C did not furnish enough heat, but a temperature of 80°C produced stickiness and caking of PB-RDX.

#### Origin:

An explosive consisting of RDX coated with polystyrene plasticized with dioctyphthalate was initially developed in 1952 for the Atomic Energy Commission by Los Alamos Scientific Laboratory of the University of California (Contract W-7405-Eng 36 with U. S. Atomic Energy

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#### PB-ROX

Commission, Report No. LA-1448). The specific formulation of 90/8.5/1.5 RDK/polystyrene/ dioctylphthclate was subsequently standardised by Los Alamos. This explosive, originally designated PHX, has been redesignated PB-RDK. The detailed requirements for the present polystyrene-bonded RDK(PB-RDK) are given in purchase description X-PA-PD-1088, 25 October 1956.

## References; 53

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(a) B. J. Zlotucha, T. W. Stevens and C. E. Jacobson, <u>Characteristics of Polystyrene-</u> Bonded RDK(PB-RDK), PATR No. 2497, April 1958.

(b) A. J. Pascasio, The Suitability of a Bare PRX Booster Pellet in the 2.75 Inch NL HEAT Rockst Head, PATR No. 2271, November 1955.

(c) J. L. Vermillion and R. C. Dubberly, <u>Plastic-Bonded PDK</u>, <u>Its Preparation by the Slurry</u> <u>Method</u>, Holston Defense Corporation, Control No. 20-7-16 Series A (PAC 1081), 5 March 1953.

(d) C. J. Eichinger, <u>Report on Cartridge HEAT 57 mm M307A1 (Mod) with Modified Copper</u> <u>Liner</u>, Abertheen Proving Ground, Development and Proof Services, First Report on OC Project TA3-5204, October 1957.

<sup>53</sup>See footnote 1, page 10.

#### Pentserythritol Trinitrate (PETRIN)

AMCP 706-177

Composition: 96	Melocular Weight: (C5H9N3010)	271
70 C 22.1	Oxygen Belance:	
CHONOS	CO, %	-27
H 3.3	CO %	33
HOCH2 - CH20NO2	Density: gm/cc	1.54
0 59-1 CH20NO2	Malting Point: *C	26 to 28
C/H Ratio 0.141	Freezing Point: *C	
Impost Sanshivity, 2 Kg Wt:	Beiling Point: *C 4 mm Hg Decompose	s 130
Bureau of Mines Apparatus, cm Sample Wt 20 mg	Refractive Index. ng	
Picatinny Arsenal Apparatus, in. 5 to 10	-	
Sample Wt, mg 38	n <u>S</u>	
	ng	
Friction Pandulum Test:	Vocuum Stability Test:	
Steel Shoe	cc/40 Hrs, at	
Fiber Shoe	90°C	
	10C°C	2.54 to 5.0
Rifle Bullet Impact Test: Trials	120°C	
<b>%</b>	135°C	
Explosions	150°C	
Porticis		
Burned	200 Grom Bomb Sand Test:	
Unoffected	Sand, gm	
Explosion Temperature: *C	Sensitivity to initiation:	
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gm	
1	Morcury Fulminate	
5	Lead Azide	
10	Tetryi	
15		
20	Ballistic Minter, % TNT:	
75°C International Host Test:	Treast Test, % TNT:	
% Loss in 48 Hrs	Plate Dant Test:	
	Method	
100°C Hest Test:	Condition	
% Loss, 1st 48 Hrs	Confined	
% Loss, 2nd 48 Hrs	Density, gm/cc	
Explosion in 100 Hrs	Brisonce, % TNT	
Flormability Index:	Detenation Rate:	
	Confinement	
Humananalahu. K	Condition	
Hygroscopicity: %	Charge Diameter, in.	
Volatility:	Density, gm/cc	
	Rote, meters/second	

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2.40 W.S.

## AMCP 706-177

### Pentaerythritol linitrate (PETRIN)

Frequentation Yest:	Shoped Charge Effectiveness, TNT $=$ 100:
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth
Total No. of Fragmants: For TNT	Color: White
For Subject HE <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	Principel Uses: Explosive, propellant or igniter ingredient
Total No. of Fragmonts: For TNT For Subject HE	Method of Looding:
Fragment Velocity: ft/sec	Looding Density: gm/cc
At 9 ft At 25½ ft Density, gm/cc	Storege:
Blast (Relative to TNT):	Method Dry Hazard Class (Quantity-Distance)
Air: Peak Pressure	Compatibility Group
Impulse Energy	Exudation None
Air, Con-Inod: Impulse	PETRIN esters are listed in reference (b) and most of these esters have been shown to have explosive properties.
Under Water: Pent: Pressure Impulse Energy Absolute Viscosity, poises: Temp, 17°C 14.8 23°C 4.3 28°C 3.0 38°C 1.2	An infrared spectrophotometric procedure was developed for the determination of the acetone content of PETRIN (ref c). A 2.5 gm sample of PETRIN is dissolved in chloroform and the volume increased to 25 milliliters in a volumetric flask. The acetone content of the PETRIN solution is determined by its infra- red absorption at 5.82 $\mu$ in a 0.5 mm cell. A double beam method is used with a reference cell containing chloroform and acetone-free PETRIN. The quantity of the latter must be carefully adjusted to give a good balance be- tween the test sample and reference cells for the strong PETRIN peak at 6.02 $\mu$ maximum. <u>Heat of:</u> Explosion, cal/gm 1204

1000

#### Pentacrythritol Trinitrate (PETRIN)

Preparation:

P

с(сн <sub>2</sub> он) <sub>4</sub> +	3HINO 3	H2SO1	онсн <sub>2</sub> с(сн <sub>2</sub> no3,3	+	3H20	
entaerythritol	nitric	sulfuric	pentaerythritol trinitrate		water	
MW 136	acid MW 63	acid MW 98	MW 271		MW 18	

The earlies procedure used for the manufacture of PETRIN was that developed at Alleghany Ballistics Laboratory. In this process, called the "A process," 80% HNO, and the solid pentaerythritol were charged to the reactor and 80% H<sub>2</sub>SO<sub>4</sub> was added slowly it a rate to permit control of temperature at 0° to 5°C. This mixture was held for a 2-1/2-hour reaction period, then drowned in water and filtered to give a cake containing both the tri- and tetra-nitrates of pentaerythritol. The cake was dissolved in acetone and neutralized in solution with ammoniu carbonate, after which the PETN and precipitated by the addition of water. After filtration, the PETRIN was recovered from the filtrate by stripping off the solvent under vacuum. Yields by this process averaged about 40%.

An improved process, called the "B process," used the same primary reaction procedure but a different work-up procedure. After the reaction holding pericd, water was added to dilute the mixed acid and the batch was extracted in situ with methylene chloride. The organic layer was separated, neutralized with aqueous sodium bicarbonate, and stripped of methylene chloride under vacuum to yield the product directly. Yields by this process were about 50% and quality of the product was much improved over that of the "A process."

The "C process," currently in use, involves essentially the simultaneous synthesis and extraction of PETRIN from the reaction mixture. Methylene chloride approximately equal to the total weight of the other components is added to the reaction mixture before the sulfuric acid. After a suitable time following the addition of sulfuric acid, the solvent is removed and remarked by fresh solvent one or more times. The combined extracts are neutralized and concentrated. Because of their initially relatively large volume, PETN man, be removed by filtration from the concentrated PETRIN solution before the final solvent is stripped. Yields by this process have been 60% to 65%.

#### Origin:

The nitration products of pentaerythritol or itc derivatives containing not more than three NO2 groups were petented for use as explosives, propellants or ignition materials in 1936 (German Patents 638,432 and 638,433; CA 31, 1212 (1937)).

A process in which pentaerythritol monoacetate was converted to pentaerythritol trinitrate monoacetate, which was then saponified under carefully controlled conditions to PETRIN, was reported in 1954 (N. S. Marans, L. E. Elrick and R. F. Preckel, J Am Chem Soc  $\underline{70}$ , 1304). "TTRIN was also prepared by the nitration of pentaerythritol with a mixture of  $\underline{805}$  HNO<sub>3</sub> and  $\underline{805}$  H<sub>2</sub>SO<sub>4</sub> in 1955 (A. T. Camp, N. S. Marans, D. E. Elrick and R. F. Preckel, J Am Chem Soc  $\underline{11}$ , 751).

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#### Pentaerythritol Trinitrate (PETRIN)

### References:54

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(a) Rohm and Haas Company, Redstone Arsenal Division, <u>Process for the Manufacture of</u> <u>Pentaerythritol Trinitrate Monoscrylate and Petrin Acrylate Propellanis</u>, 12 Mar. 1956.

(b) E. Berlow, R. H. Barth and J. E. Snow, <u>The Pentaerythritols</u>, ACS Monograph No. 136, p. 65, Reinhold Publishing Corporation, New York, 1958.

(c) R. H. Pierson, <u>An Infrared Spectrophotometric Method for Determination of Acetone</u> <u>Content of Pentaerythritoltrinitrate</u>, U.S. Havel Ordnance Test Station Report ROTS 15.7; HAVORD Report No. 5649, 3 February 1958.

54see footnote 1, page 10.

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#### Pentaerythritol Trinitroscrylate (PETRIN Acrylate) (Trinitroxypentaerythritol Acrylate)

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Composition: %	Melecular Weight: (C8H11N3O11) 325
C 29.5	Oxygen Belonce:
CH2UNO2	CO <sub>2</sub> % -54 CO% -12
	CO % -12
N 12.9 $CH_2 = CI - CO_2 CH_2 C - CH_2 ONO_2$	E ensity: gm/cc
0 54.2 CH20NO2	Metting Point: "C 78 to 79
C/H Ratio 0.239	Freezing Point: "C
Impact Sansitivity, 2 Kg Wt:	Beiling Peint: "C
Bureau of Mines Apparatus, cm Sample Wt 20 mg	Refrective Index, nº
Picatinny Arsenal Apparatus, in.	
Sample Wt, mg	nB
	n <b>b</b>
Friction Pondulum Test:	Vecuum Stability Test:
Steel Shoe	cc/40 Hrs, at
Fiber Shoe	90°C
Rifle Bullet Impact Text: Trials	100°C
•	120°C
Explosions %	135*C
Partials	150°C
Burned	
Unoffected	200 Gram Bomb Send Tert:
	Sond, gm
Explosion Temperature: °C	Sensitivity to Initiation:
Seconds, 0.1 (nu cop used)	Minimum Detonating Charge, gm
1	Mercury Fulminate
5	Lead Azide
10	Tetryl
15	
20	Bellistic Morter, % TNT:
75°C International Heat Test:	Trouzi Test, % TNT:
% Loss in 48 Hrs	Plete Dent Test: Nethod
100°C Heat Test:	Condition
% Loss, 1st 48 Hrs	Confined
% Loss, 2nd 48 Hrs	Density, gm/cc
Explosion in 100 Hrs	Brisance, % TNT
Flammability Index:	Detenc''n Rote:
	Confinement
Hygrescepicity: % Nil	Condition
	Charge Diameter, in.
Veletility:	Density, gm/cc
•	Rate, meters/second

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#### Pentaerythritol Trinitroscrylate (PETRIN Acrylate)

Fregmentation Test:	Shaped Charge Effectiveness, TNT == 100:	
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Concs Hole Volume Hole Depth	
Total No. of Fragmants: For TNT	Celor:	white
For Subject HE <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	Principel Uses: Ingredient of composite rocket propellants	
Total No. of Fragmonts: For TNT	Mathod of Looding:	<u></u>
For Subject HE	Leading Density: gm/cc	
Fregment Velecity: ft/sec At 9 ft At 25½ ft Density, gm/cc	Storege: Method Dry at temperatures bei melting po	
Biest (Relative to TPIT):	Hazard Class (Quantity-Distance)	JIAC
Air: Peok Pressure Impulse Energy	Compatibility Group Exudation	None
Air, Cenfilled: Impulse Under Water: Peak Pressure	. <u>Heat of:</u> Combustion, _h/gm Explosion, cal/gm	2923 791
im ulse Energy		
Uaderground: Peak Pressure Impulse Energy		

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#### Pentaerythrical Trinitroscrylate (PETRIN Acrylate)

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Preparation:	(a)		
HOCH2C(CH2NO3)3	+ CH <sub>2</sub> = CHCOCI	. + с <sub>б</sub> н	5 <sup>N</sup> (CH <sub>3</sub> ) <sub>2</sub>
pentaerythritol trinitrate (PETRIN) MW 271 Q	acrylyl chloride MW 90.5	an	ethyl iline / 121
(о <sub>2</sub> мосн <sub>2</sub> ) зссн <sub>2</sub> оссн	- сн <sub>2</sub> + с <sub>6</sub> н	15N(CH3)2HC1	<b>←</b>
pentaerythritol trinit acrylate (PETRIN acry		methylanine drochloride	

MW 325 The original synthesis for PETRIN acrylate employed trifluoroacetic anhydride and glacial acrylic acid as the acrylation agent for PETRIN. These two materials were charged to a reaction vessel and the initial reaction was controlled by the slow addition of PETRIN at a temperature of  $10^{\circ}$  to  $15^{\circ}$ C. Following a period of one hour, the batch was drowned in water, precipitating the PLIRIN acrylate. This solid was separated by filtration, dissolved in chloroform, and neutralized it solution with sodium bicarbonate. The product was then crystallized during a period of 16 hours at  $0^{\circ}$ C and dried under vacuum to remove traces of solvent. The yield for this process was about 60%.

A significant improvement in yield (to about 74%) and purity (approximately 90%) was realized by the substitution of methanol for chloroform and crystallization of the product from the solution without neutralization, residual acid being removed by washing the filter cake with water.

Because of the high cost and hygroscopic nature of trifluoroacetic anhydride, a new process, based on dimethylaniline and acrylyl chloride, was considered. This process is currently under development in the Rohm and Haas Chemical Processing facilities and is not considered optimum. Yields averaged 46% and product purities averaged 93.5%.

#### PETRIN Acrylate Propellants:

PETRIN acrylate could be used as a monopropellant because it has a specific impulse of 214 lb-sec/lb and a burning rate of 0.2 in/sec. The addition of an exidizer increases both the impulse and burning rate.

A composition which presently appears most promising is as follows:

	Composi	tion NM
PEIRIN acrylate (> 97% purity), %	34.3	(binder)
Triethylene glycol frinitrate, 🖇	11.8	(plasticizer)
Glycol diacrylate, 🖇	2.9	(crosslinker)
Ammonium perchlorate, %	51.0	(oxidizer)
Hydroquincne, %	0.014	(polymerization inhibitor)

Measured specific impulse 238 lb-sec/lb, at density of 1.3.

## Reference:55

(a) Rohm and Haas Company, Redatone Arsenal Division, Process for the Manufacture of Pentaerythritol Tetranitrate Monoacrylate and Petrin Acrylate Propellants, 12 March 1956.

55See footnote 1, page 10.

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## Pentolite, 50/50; 10/90

Composition:			Melecular Weight:	<u>50/50</u> 205	<u>10/90</u> 234	
%			Oxygen Belence:			
PETN	50	10	CO: % CO %	-42 - 5	-68 -21	
INT	50	90	Density: gm/cc	1.65	1.60	-
			Melting Point: °C		76	┥
C/H Ratio			Freezing Point: "C			-
impect Cercitivity	. 2 Ka Wt:	50/50 10/90	Beiling Point: *C			
Bureriu of Min	es Apparatus, cm	<u>50/50 10/90</u> 34 65		·····		-
Somple Wt 2 Picatinny Arse Sample Wt, n	nal Apparatus, in.	12 14 15 18	Refrective Index, ng ng ng			
Friction Pondulur Steel Shoe Eiber Shoe	n Test:	Unaffected Unaffected	Vecuum Stability Test: cc/40 Hrs, at 90°C	50/50	10/90	
			- 100°C	3.0	3.0	
Rifle Bullet lange	et Test: 25 Trials,	50/50	120°C	11+	11+	
Explosions	% 72		135°C			
Portials	20		150°C	**	**	
Burned	0		209 Grem Bomb Send Test:			
Unoffected	8		Sond, gm	55.6	49.5	
Explosion Tumpo Seconds, 0,1 (	ino cop used) 290	50/50	Sensitivity to Initiation: Minimum Detonating Ch	arge, gm	<u>50/50</u>	
1	266		Mercury Fulminate		0.19*	
	ecomposes 220		Lead Azide		0.13*	
10	204 197		Tetryl *Alternative initiati	ng charges		
15 20	>190		Bellistic Morter, % TNT:	(a)	126	
			Trevizi Test, % TNT:	(b)	122	
<b>75°C Internation</b> % Loss in 48			Plate Dent Test: Method	(c)	Б	
100°C Heat Test	<u>,</u>	50/50	Condition		Cast	
% Loss, 1st 4		0.0	Confined		No	
% Loss, 1st 4		0.2	Density, gm/cc		1.66	
Explosion in 10		None	Brisonce, % TNT		121	
Flemmebility Ind	ex: Will not cor	ntinue to burn	- Detonation Rate: Confinement		lione	
			- Condition		Cast	
Hygracopicity: ' 30°C, 90% F	% <u>50/50</u>		Charge Diameter, in.		1.0	
	H None	lione	Density, gm/cc		1.66	
Volatility:			Rate, meters/second		7465	- 1

	Pencorrie	<u>, 50/50; 10/40</u>	
Booster Sensitivity Test: (d)	50/50	Decomposition Equation:	
Condition Pressed	Cast	Oxygen, atoms/sec (Z 'sec)	
Tetryl, gm 100	100	Heat, kilocalorie/mole	
Wax, in. for 50% Detonation 2.36	2.08	(1H, kcal/mol)	
Wax, gm	. /-	Temperature Ronge, °C	
Density, gm/cc 1.60	1.65	Phase	
Heat of: Combustion, cal/gm		Armor Plate Impact Test:	<u>50/</u>
Explosion, cal/gm	1220	60 mm Mortur Projectile:	
Gas Volume, cc/gm		50% Inert, Velocity, ft/sec	17
Formation, cal/gm		Aluminum Fineness	
Fusion, col/gm		300-16 General Purpose Bambs:	
<b>Specific Heat:</b> col/gm/°C		Plate Thickness, inches	
		1	
		$10_4$	
		11/4	
		13,	,
Surning Rate: cm/sec			
Cm/ sec		Bomb Drop Test:	
Thermal Conductivity: cal/sec/cm/°C		T7, 2000-16 Semi-Armor-Piercing Bor	nb vs Concr
Coefficient of Expension:		Max Sufe Drop, ft	
Linear, %/°C		500-lb General Purpose Bomb vs Con	ncr <b>ete</b> :
Volume, %/°C		Height, ft	
Mandanana Adabat Baalaa		Trials	
Herdness, Mohs' Scele:		Unarfected	
Young's Modulus:		Low Order	
E', dynes/cm <sup>2</sup>		High Order	
E, lb/inch <sup>2</sup>			
Density, gm/cc		1000-lb General Purpose Bamb vs Co	nerata:
		Height, ft	
Compressive Strength: Ib/inch <sup>2</sup> 20	00-2200	Trials	
Density, gm/cc	1.68	Unoffected	
Vapor Pressure:		Low Order	
°C mm Mercury		High Order	
		-	

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## Pentolite, 50/50; 10/90

Fregmentation Test:	<u>50/50</u>	Sheped Charge Effectivenese, TNT = 100: <u>50/50</u> 10/90 50/50 25/	75
90 mm HE, M71 Projectile, Let WC-91:		Gloss Cones(1) Steel Cones	
Density, gm/cc	1.65	Hole Volume 157 105 149 11	9
Charge Wt, Ib	2.147	Hole Depth 116 116 131 11	9
Total No. of Fragmants:		Celer: Yellow-whi	te
For TNT	703		
For Subject HE	968	Principal Uses: Shaped charges, burst	•
3 inch HE, M/IZA3 Projectile, Let KC-5:		charges, demolition b	locks
Density, c.m/cc	1.65		
Charge Wt, Ib	0.872		
Total No. of Fragments:		Method of Leading:	Cast
For TNT	514		
For Subject HE	650	Looding Density: gm/cc 50/50	10/90
Fregment Velecity: ft/sec		1.65	
At 9 ft	2810		
At 251/2 ft	2580	Storage:	
Density, gm/cc	1.66	Method	Dry
Blast (Relative to TNT):	(e)	Hazard Class (Quantity-Distance)	Class 9
Air:		Compatibility Group	Group I
Peak Pressure	105		
Impulse	107	Exudation	
Energy	••		
		Compatibility with Metals:	
Air, Caafined: Impulse		Dry: Copper, brass, aluminum, mag	
		magnesium-aluminum alloy, mild steel with acid-proof black paint, and mild	
Under Weter:		plated with copper, cadmium or nicke	
Peak Pressure		affected. Zinc plated steel is only	slightly
Impulse		affected.	
Enurgy		We:: Stainless steel, aluminum an steel conted with acid-proof black pa	int are
Underground:		not aife ted. Copper, brass, magnes	lum, mag-
Peak Pressure		nesium-aluminum alloy, mild steel and steel plated with copper, cadmium, zi	
impulse		nickel are slightly affected.	
Energy			(h)
Eutectic Temperature, <sup>O</sup> C:	76	Rate of Detonation: 50	/50
gm PEIN/100 gm INT		16 hrs at, <sup>O</sup> C -54 Density, gm/cc 1.67	21 1.66
76°c	13.0	Rate, m/sec 7470	7440
95°C	28.3		1440

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#### Pentolite, 50/50; 10/90

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#### Preparation:

Pentolite is manufactured by either the slurry method or coprecipitation of PEIN and INT. In the slurry method PEIN, in water, is stirred and heated above  $80^{\circ}$ C. INT is added and when molten, it coats the particles of PEIN. The slurry is cooled with rapid stirring and the separated granules are collected on a filter and dried below  $75^{\circ}$ C.

In correctipitation, PEIN and TNT are dissolved separately in acctume. The solutions are mixed and the explosives are precipitated simultaneously by pouring the mixed solution into cold water under vigorous agitation. The precipitated solid is collected on a filter and dried in air.

#### Origin:

Sec. Sec.

Standardized during World War II, with the 50-50 PETN/INT mixture being the more important for bursting charges and booster-surround charges.

#### References: 56

(a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Second Revision, NAVORD Report No. 87-46, 26 July 1946.

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> Tetryl in Boosters, NOL Memo 10,303, 15 June 1949.

(e) W. R. Tomlinson, Jr., <u>Elast Effects of Bomb Explosives</u>, PA Tech Div Lecture, 9 April 1948.

(f) Bastern Laboratory, du Pont, <u>Investing: on of Cavity Effect</u>, Sec III, Variation of <u>Cavity Effect with Explosive Composition</u>, NDRC Contract W572-ORD-5723.

(g) Eastern Laboratory, du Pont, <u>investigation of Cavity Effect</u>, Final Report, Contract W-672-ORD-5723, E. Lab, du Pont, 18 September 1943.

(h) W. F. McGarry and T. W. Stevens, Detonation Rates of the More Important Military Explosives at Several Different Temperatures, PATR No. 2383, November 1956.

(1) Also see the following Picatinny Arsenal Technical Report on Pentolite:

<u>o</u>	<u>1</u>	2	3	4	٤	6	<u>7</u>	8
1360 1420 1570	1291 1451 1651	1212 1262 1372	1133 1193 1213 1363	1284 2004	1325	1436 1466 1796	1477 1677 1737	1388 1598 1668 1838

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## PEIN (Pentaerythritol Tetranitrate)

Composition: %		Molecular Weight: (C <sub>5</sub> H <sub>8</sub>	N4012)	316
0 19.0 0NO <sub>2</sub>		Oxygen Belance:		
H 2.5		CO. %		-10 15
$0 - NO - CH_{-} - C - CH_{-}$	- CNO			
	22		ystal	1.77
0 <b>60.</b> 8 <sup>CH</sup> 2		Melting Point: °C		141
C/H Rctio 0.134 0N02		Freezing Point: °C		
Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	17	<b>Boiling Point:</b> °C		
Sample Wt 20 mg	•	Refrective Index, no		
Picatinny Arsenal Apparatus, in. Sample Wt, mg	6 16	n23		
		n <sub>so</sub>		
Friction Pondulum Test:		Vacuum Stability Test:		
Steel Shoe C	reckles	cc/40 Hrs, at		
Fiber Shoe U	naffected	90°C		
Sifle Sullet Impact Test: 5 Trials *		- 100°C		0.5
%		120°C		11+
Explosions 100		135*C		
Partials 0		150°C		
Burned 0		200 Grem Bomb Sand Test:		
Unoffected 0 #4.800 moisture in samples		Sand, gm		62.7
Explosion Temperature: °C		Sensitivity to Initiation:		
Seconds, 0.1 (no cap used) 272		Minimum Detonating Ch	arge, gm	
1 244		Mercury Fulminate		0.17*
5 Decomposes 225		Leod Azide		0.03*
10 211		Tetry! *Alternative initiatin	-	
15		Bellistic Morter, % TNT:	(a)	145
20		Trauzi Test, % TNT:	(u) (b)	173
5°C International Heat Test:				1,5
% Loss in 48 Hrs	0.02	Plate Lent Test: Method	(c)	A
00°C Heat Test:		Condition		Pressed
% Loss, 1st 48 Hrs	0.1	Confined		Yes
% Loss, 2nd 48 Hrs	0.0	Density, gm/cc		1.50
Explosion in 100 Hrs	None	Brisance, % TNT		129
		— Detonation Rate:		
Flammebility Index: Will not continu	e to burn	Confinement		None
		- Condition		Pressed
<b>tygroscopicity: % 30<sup>0</sup>C,</b> 90% RH	0.0	Charge Diameter, in.		1.00
		Density, gm/cc		1.70
/olatility:	0.0	Rate, meters/second		8300

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### PETN (Pentaerythritol Tetranitrate)

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ALC: NO

Pressed	Decomposition Equation: (e) (e) (f) Oxygen, atoms/sec 10 <sup>19.8</sup> 10 <sup>20.6</sup> 10 <sup>23.1</sup>
5	(Z/sec)
	Heat, kilocalorie/mole 47.0 50.9 52.3 (AH, kcal/mol)
3	Temperature Range, °C 161-233 108-120 137-157
1.6	Phose Liquid Solid At mel
1960	Armer Plate Impact Tast:
1385	
790	60 mm Monter Projectile: 50 % Inert, Velocity, ft/sec
383	Aluminum Fineness
	500-16 General Purpose Bombs:
(d)	
	Plate Thickness, inches
0.26	
	11/4
	11/2
	134
	Bomb Drop Test:
	T7, 2000-1b Semi-Armor-Piercing Bomb vs Concrete:
	Max Safe Drop, ft
	500-16 General Purpose Bomb vs Concrete:
	Height, ft
· · · · · · · · · · · · · · · · · · ·	Trials
1.9	Unaffected
	Low Order
	High Order
	1000-lb General Purpose Bomb vs Concrete:
	Height, ft
	Trials
	Unoffected
	Low Order
	High Order
	1.6 1960 1385 790 383 (d) 0.26

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## PETN (Pentserythritol Tetranitrate)

Fragmentation Test:	Shaped Charge Effectiveness, TNT = 1	)0:
90 mm HE, M71 Projectile, Let WC-91:	Glass Cones Steel C	00000
Density, gm/cc	Hole Volume	
Charge Wt, Ib	Hole Depth	
Tatul No. of Fragments:		
For TNT	Color:	White
For Subject HE		
3 inch ME, M42A1 Projectile, Let KC-5:	Principal Upon: Class A - Detonating fuse and	boosters
Density, gm/cc	Class B - Priming composition	15
Charge Wt, Ib		
Total No. of Fragments:		
For TNT	Mathed of Loading:	
For Subject HE		
	Looding Density: gm/cc ps: x	103
Fregment Velocity: ft/sec	5 5 10 20 30 1.37 1.58 1.64 1.71 1.73	
At 9 ft At 251/2 ft	Storage:	
Density, gm/cc	Method	Wet
		wet
Blact (Relative to TNT):	Hozard Closs (Quantity-Distance)	Class 9
Air:	Compatibility Group	Group M (wet)
Peak Pressure Impulse	Exudation	
Energy	Exudation	None
5 <b>6</b> 9 7		
Air, Confined:	Bulk Modulus at Room Temperature (25-30°C):	(1)
Impulse		
Under Water: Peak Pressure	Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> Density, gm/cc	4.60 1.77
Impulse		
Energy		
Underground: Pook Pressure		
Impulse		
Energy		
•		

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### PETN (Pentaerythritol Tetranitrate)

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### Compatibility with Netals:

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Dry: Copper, brass, aluminum, magnesium, magnesium-sluminum alloy, stainless steel, mild steel, mild steel coated with acid-proof black paint and mild steel plated with copper, cadmium, nickel or zinc are not affected.

<u>Vet:</u> Stainless steel is unaffected and aluminum only vary slightly so after prolonged storage. Copper, brass, magnesium, magnesium-sluminum alloy, mild steel, mild steel coated with acid-proof black paint and mild steel plated with cadmium, copper, nickel or zinc are affected.

Sensitivity of PEIN to electrostatic discharge, joules; Through 100 Mesh: (g)

Unconfined	0.06
Confined	0.21

Solubility, grams of PETW per 100 grams (%) of: (h)

	cohol	Ac	etone	Be	nzene	To	luene
°c	乏	<u>°c</u>	£	°c	差	°c	ž
0 20 40 60	0.070 0.195 0.415 1.205	0 20 40 60	14.37 24.95 30.56 42.68	0 20 20 80	0.150 0.450 1.160 7.900	0 20 40 60 80 100	0.150 0.430 0.620 2.490 5.850 15.920 30.900

							50.700	
Methyl acetate		Eth	Sther L		e-Ethoxy-ethyl- acetate		Chlorobenzene	
°c	z	°c	£	<u>°c</u>	ž	°c	É	
20 30 40	13 17 22	0 2 <b>0</b> 34.7	0.200 0.340 0.450	20 30 40	1.5 4.1 7.6	20 30 40	0.35 2.8 6.1	
50	31			50 60	11.2 14.2	50 60	9.2 12.2	

Ethylen	edichloride	Meth	anol	Tetrach	loroethane	Car tetrac	bon hloride
<u>°c</u>	٤	°c	\$	<u> 20</u>	£	°c	ž
10	0.9	20	0.46	20	0.18	20	0.096
30	1.5	40	1.15	30	0.27	30	0.108
50	2.6	60	2.6	40	0.40	40	0.118
				50	0.58	50	0.121

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PETN (Pentaciv'aritol Tetran'trate)

£ 19.3 25.0 32.1 39.5 48.6 58.2 70.0 87.8

115

161

120

125

Is	opropanol	Isobu	itanc?	Chlo	roform		TNT
°c	٤	°c	ž	<u>°c</u>	Ł	<u>°c</u>	
15	0.02	20	C 27	20	0.07	80	
20	0.04	30	0.31			85	
30	0.15	40	0.39			90	
30 40	0.36	50	0.52			95	
50	0.46		E .			100	i
						105	
	Eutetic of the	system PET	N-TNT is abo	ut 13% PET	N	110	
	and 87% INT at	76°C.				115	8

#### Preparation:

#### (Nitroglycerin and Nitroglycerin Applosives, Nacom)

8HCH0 + CH<sub>3</sub>CH0 + Ca(OH)<sub>2</sub>  $\rightarrow$  2C(CH<sub>2</sub>OH)<sub>4</sub> + Ca(HCOO)<sub>2</sub> C(CH<sub>2</sub>OH)<sub>4</sub> + 4HNO<sub>3</sub>  $\rightarrow$  C(CH<sub>2</sub>ONO<sub>2</sub>)<sub>4</sub> + 4H<sub>2</sub>O

1. In this preparation 1940 gm of formsldehyde and 600 gm of acetel.ich, de are dissolved in 90 liters of water containing 1600 gm suspended slaked lime. The reaction is complete in about 3 weeks if agitated several times a day. The solution is filtered, the calcium formate precipitated with complic acid, filtered off, and the water removed under reduced pressure. On cooling the mother liquor about 1200 gm crude pentaery-thritol, melting point 235°-240°C are obtained. Purification is readily effected by stirring with a little alcohol, filtering and recrystallization from water.

2. T. 400 cc of strong white nitrianid, are added 100 gm of pentaerythritol (through 50 mesh), at  $5^{\circ}$ C or below, under good as stion. After addition is complete stirring, at  $5^{\circ}$ C, is continued for 15 minutes. The mixture is drowned in 3 liters of ice-water, filtered, the product washed free of acid with water and then digested 1 hour in 1 liter of hot 0.5% sodium carbonate solution. The product is filtered, and recrystallized from acetone.

#### Origin:

PETN was known as an explosive in 1694 when it was proposed as an addition to smokeless powders to raise their flammability and case of combustion (German Patent <u>81,664</u> (1894). Modern methods of proparation are described by Vignon and Gerin (Compt rend <u>133</u>, 590 (1901) and German Patent 265,025 (1912) and A. Stettbacher (Z ges Schiess - Sprengst fiv <u>11</u>, 112, 102 (1916) and <u>24</u>, 259 (1929). PETN was not used on a practical basis until after World War I.

#### Destruction by Chewical Decomposition:

PETN is a compore by dissolving in 8 times its weight of technical grade acctone and burning the solution 1 a shallow container. If preferred, where the acctone solution to  $40^{\circ}$ C, stir and add 7 parts by weight, to each part of PFTN, of a solution of 1 part sodium sulfide (Na<sub>2</sub>S·9H<sub>2</sub>O) in 2 parts water heated to 80°C. The agreeus solution should be added at such a rate that the acctone solution does not buil. After mixing is complete continue stirring for one-half hour.

#### PETN (rentaerythritol "etranitrate)

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### References:57

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(a) L. C. Smith and E. G. Hyster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Testu; Performance Tests. OSRD Report No. 5746, 27 December 1945.

(b) Ph. Naoum, <u>Z ges Schiess</u> - Sprengstoffw, pp. 181, 229, 267 (27 June 1932).

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) International Critical Tables.

(e) M. A. Cook and M. T. Abegg, "Isothermal Decomposition of Explosives," University of Utah, <u>Ind & Eng Chem</u>, (June 1956), pp. 1090-1095.

(f; A. J. E. Robertson, "The Thermal Decomposition of Pencaerythritol Tetranitrate, Nitro-Slyceri:. Ethylenediamine Dinitrate and Ammonium Nitrate," J Chem Ind <u>67</u>, 221 (1948).

(g) F. W. Brown, D. H. Kusler and F. C. Gibson, <u>Sensitivity of Explosives to Initiation</u> by <u>Electrostatic Discharges</u>, U.S. Dept of Int, Bureau of Mines, RI 3852, 1946.

(h) Various sources in the open literature.

(i) W. S. Cramer, <u>Bulk Compressibility Data on Several High Explosives</u>, NAVORD Report No. 4380, 15 September 1956.

(J) Also see the following Picatinny Arsenal Technical Reports on PETN:

<u>o</u>	<u>1</u>	2	3	4	2	6	Ţ	8	2
760 1170 1260 1390 1320 1360 2380 1390 2430 1450 1570	1041 1311 1381 1451 1561 1611 1651	772 922 1182 1192 1212 1262 1352 1352 1352 1372 1452	643 863 1063 1133 1253 1343 1493 1533	904 1274 1284 1414	1305 1325 1445 1705 1885 2125	1246 1276 1316 1376 1446 1456 1556 1796	407 527 857 1247 1517 1617 1737 1797	318 533 1238 1318 1388 1568 1558 1830 2178	1379 1429 1489 1559 2179

<sup>17</sup>See footmote 1, page 16.

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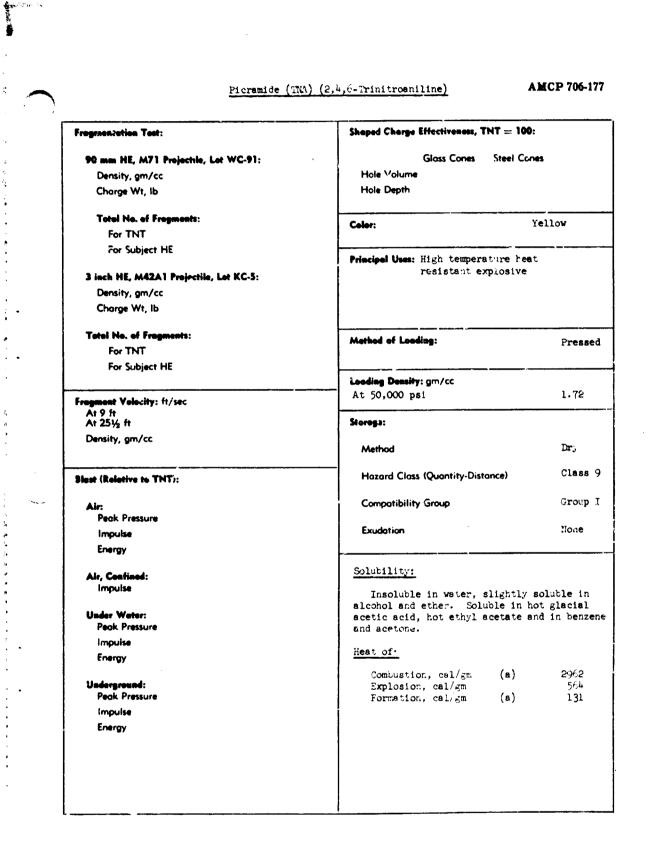
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### Picramide (TNA) (2,4,6-Trinitroaniline)

Composition:	Aclecular Weight: (C6H4N4O6)	228
96 C 31.5	Oxygen Belence:	_
	CO- % CO %	-56 -14
H 1.8 $O_2 N \longrightarrow NO_2$		-1-
N 24.5	Density: gm/cc Crysta	1 1.76
0 42.2 NO2	Melting Point: °C	189 to 190
C/H Ratio 0.500	Freezing Point: *C	
mpoer Sensitivity, 2 Kg Wt:	Boiling Point: *C Decomposes be	fore boiling point
Bureau of Mines Apparatus, cm Sample Wt 20 mg	Refrective Index, no	
Picatinny Arsenal Apparatus, in. 23	n <sup>o</sup>	
Sample Wt, mg 20		
	n‰	·····
Friction Pendulum Test:	Vocuum Stability Test:	
Steel Shoe	⊴c/40 Hrs, at : 90°C	
Fiber Shce		0.9
Rifle Bullet Impact Test: Trials	120°C	0.9
- %	135°C	
Explosions	150°C	
Partic's	130 C	
Burned	200 Gram Bomb Sand Test:	
Unaffected	Sand, gm	48.2
Explosion Temperature: °C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gm	
1	Mercury Fulminote	
5	Leod Azide	0, 30
10	Tetryl	
15	Ballistic Morter, % TNT:	100
20	Trougi Test, % TNT:	107
75°C International Host Test:	Plate Dent Test:	-
% Loss in 48 Hrs	Method	
	/ Condition	
100°C Heet Test:	Confiried	
% Loss, ist 48 Hrs % Loss 2nd 49 Hrs	Density, gm/cc	
% Loss, 2nd 48 Hrs	Brisance, % TNT	
Explosion in 100 Hrs		<u> </u>
Flemmebility Index:	Detonation Rate: Confinement	None
	Continement Condition	None Pressed
Hygroscopicity: %	Charge Diameter, in.	0.5
	Density, gm/cc	1.72
Yeletility:	Density, gin/ CC	* * I /-

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#### Picramide (TNA) (2,4,6-Trinitroaniline)

#### Preparation:

Five grams of picryl chloride were dissolved in 180 milliliters of absolute methanol. The solution was then satureled with anhydrous, gaseous ammonia. The time required was approximately 30 minutes. The amino derivative precipitated in 78% yield (3.6 gm) melting at 190°C (literature MP 189°C).

#### Origin:

Picramide (2,4 o-trinitroaniline) was first prepared in 1854 by Pisani who treated picryl chloride with am onium carbonate (CR 39, 853). The use of picramide, as a brisant explosive, was patended by Chemische Fabrik Griesheim 26 May 1894 (German Patent 84,628). Meisenheimer and Patzig rescted trinitrobenzene with hydroxylamine in cold alcohol solution to obtain picramide (Ber 39, 2534 (1906)). Witt and Witte obtained the compound by nitrating a solution of aniline in glacial scetic acid or concentrated  $H_2SO_4$  at about 5°C with concentrated HNO<sub>3</sub> (Ber 41, 3091 (1908)). Holleman gives details of the prep ation from p-nitroaniline and from actinitie (Rec trav chim 49, 112 (1930)).

### Reference: 58

(a) William H. Rinkenbach, "The Heats of Combustion and Formation of Aromatic Nitro Compounds," J Am Chem Soc <u>52</u>, 116 (1930).

58See footnote 1, pag 10.

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Picratol, 52/45

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Composition: %		Molecular Weight:	2 વર્ણ
70 Explosive D 52		Oxygen Belence;	
		CO. % CO %	-63 -19
INT 43			-19
		Density: gm/cc Cast	1.62
		Malting Point: "C	
C/H Ratio		Freezing Point: "C	
Impact Sansitivity, 2 Kg Wt:	100	Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	100+	Refractive Index, no	
Picatinny Arsenal Apparatus, in.	17		
Sample Wt, mg	19	nz	
		n <sub>20</sub>	
Friction Pendulum Test:		Vecuum Stobility Test:	
Steel Shoe	Unaffected	cc/40 Hrs,	
Fiber Shoe	Unaffected	30 °C	
Rifle Bullet Impact Test: Trials		- 100°C	0.37
-		120 °C	0.68
Explosions 0		135°C	
Partials 0		150°C	0.7
Burned 40		200 Gram Bomb Sand Test:	
Unaffected 60		Sand, gm	45.0
Explosion Temperature: C		Sensitivity to Initiation:	
Seconds, 0.1 (no cap used) 456		Minimum Defonating Diarge, gm	
1 354		Mercury Fulminate	
5 Decomposes 285		Leas Azide	0.20
10 265		Tetryl	0.0
15 24/0			
<b>20</b> 255		Ballistic Murter, % TNT: ( )	100
75°C International Heat Test:		Treusl Tost, % TNT:	
% Loss in 48 Hrs	0.0	Plate Dant "est: (:)	
		Method	
100°C Heat Test:		Condition	<b>B B</b> *
% Loss, 1st 48 Hrs	0.0	Confined	iate. A la calcal
% Loss, 2nd 48 Hrs	0.0%	Density, gm/cc	1.1.3
Explosion in 100 Hrs	None	Brisunce, & TNT	T(#)
flammahilim ladar		Detenation Rate: (-)	
Flammability Index:		Confinement	i : €
Mygroscopicity: % 30°C, 90% RH	0.02	Condition	9 L '
HAR CONCERNENCE TO THE CONCERNENCE	0.02	Charge Diameter, in	)
Veletility:		Density, gm/cc	
· •·•·································		Rote, meters/second	· • *3

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### Picratcl, 52/48

Fregmentation Test:		Shoped Charge Effectiveness, TNT = 10	0:
90 mm HE, M71 Projectile, Lot WC-91	1:	Glass Cones Steel Co	xnes
Density, gm/cc	1.61	Hole Volume	
Charge Wt, Ib	2.075	Hole Depth	
Total No. of Fragmants:		Color: Bro	
For TNT	703	Bron	wn-yellow
For Subject HE	76 <del>9</del>	Principel Uses: AP, SAP projectiles	and hombs
3 inch HE, M42A1 Projectile, Let KC-5	i:		
Density, gm/cc	1.61		
Charge Wt, Ib	0.850		
Total No. of Fragments:		Method of Londing:	Cast
For TNT	514	meiner (* Loonny.	(ast
For Subject HE	487		
		Loading Devsity: gm/sc	1.62
Frequent Velocity: ft/sec	2500		
At 9 ft At 25½ ft	2590 2320	Storage:	
Density, gm/cc	1.62		
-		Metinid	Dry
Blast (Relative to TNT):		Hozard Class (Quantity-Distance)	Class 9
Air:		Compatibility Group	Group I
Peak Pressure	100		
impulse	100	Exudation	None at 65°C
Energy			
Ale C-Alexa		Preparation:	
Air, Cenfined: Impulse		Picratol is made by heating TN	
		90°C in a steam-jacketed melt ke sive D is added slowly, without	
Under Water:		and the mixture stirred until un	
Peak Pressure		position. This slurry is cooled	
impulse		and poured into the appropriate a component.	ammunition
Energy			
Underground:		Origin:	
Peak Pressure		Developed during World War II	
Impulse		tive, -elt-loaded AP bomb and pro	
Energy		Booster Sensitivity Test:	(c)
Bomb Drop Test:		Condition	Cast
T7, 2000-15 Semi-Armor-Pierci	Ina	Tetryl, gm Wax, in. for 50% Detonation	100 1.00
Bomb vs Concrete:	• • • • • 5	Density, gm/cc	1.63
Max Safe Drop. ft 10.000	0-12.000	1	

### Picratol, 52/48

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### References: 59

1

(a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(c) L. C. Smith and S. R. Walton, A Consideration of RDX/Wax Mixtures as a Substitute for Tetryl in Boosters, NOL Memo 10,303, 15 June 1949.

(d) R. W. Drake, Fragment Velocity and Panel Penetration of Several Explosives in Simulated Shells, OSRD Report No. 5622, 2 January 1946.

(c) Also see the following Picatinny Arse: Al Technical Reports on Picratol:

<u>o</u>	٤	<u>6</u>	Ĩ	8	2
1470	1885	1466 1796 1956	1737 1797	1838	1729

<sup>59</sup>See footnote 1, page 10.

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Picric Acid

Composition:		Molecular Weight: (C $_6$ H	3 <sup>11</sup> 307)	229
% OH C 31.5 I		Oxygen Belence:		
		CO. %		-45
H 1.3 0 <sub>2</sub> N	- NO2	CO %		- 3.5
N 18.3		Density: gm/cc	Crystal	1.76
0 48.9 Y		Melting Point: °C		122
C/H Rotio 0.656		Freezing Point: °C		
Impact Sensitivity, 2 Kg Wt:	85	Boiling Point: °C		
Bureau of Mines Apparatus, cm Sample Wt 20 mg	0)	Refractive Index, n20		
Picatinny Arsenal Apparatus, in.	13	na		
Sample Wt, mg	17	n <sup>o</sup>		
Friction Pendulurs Test:				
Steel Shoe		Vacuum Stability Test: cc/40 His, at		
Fiber Shoe		C C		
		100°C		0.2
Rifle Bullet Impact Test: Trials		120°C		0.5
Explosions 0		135°C		
Partials 60		150°C		
Burned 40		200 Gram Bomb Sand Test		
Unaffwcted 0		Sand, gm		48.5
Explosion Temporeture: °C	·····	Sensitivity to Initiation:	····	
Seconds, 0.1 (no cop used)		Minimum Detonating Cl	narge, gm	
1		Mercury Fulminate		0.26*
5 Decomposes 320		Lead Azide		0.24*
10		Tetryi *Alternative initiati	or charges.	
15		Ballistic Morter, % TNT:	(a)	112
20		"rouzi Test, % TNT:	(t)	101
75°C International Heat Test:		Plate Dent Test:	(c)	·····
% Loss in 48 Hrs	0.05	Method		A
100°C Hard Tard		Condition		Pressed
100°C Heat Test: % Loss, 1st 48 Hrs	0.03	Confined		No
% Loss, 2nd 48 Hrs	0.03 0.09	Density, gm/cc		1.50
Explosion in 100 Hrs	Kone .	Brisance, % TNT		107
		Detonation Rate:	(a)	
Flammability Index:		Confinement	(d) Un	confined
		Condition	Pressed	Cas
Hygroscopicity: % 30 <sup>0</sup> 0, 90% idi	0.04	Charge Donmeter, in.	1.0	1.25
• • • • •		Density, gr /cc	1.04	1.71
Volatility:		Rate, meters, second	2270	7350

Picrie Acid

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Booster Sensitivity Test:	(c)	Decomposition Equation:
Condition	Pressed Cast	Oxygen, atoms/sec
Tetryl, gm	10 5	(Z/sec)
Wax, in. for 50% Detonation		Heat, kilocalorie/mole (ΔH, kcal/mol)
Wax, gm	2 0	Temperature Range, "C
	1.6 1.7	Phase
Density, gm/cc	1.0 1.1	
Heat of:	6.70	Armor Plate Impact Test:
Combustion, cal/gm	2072	
Explosion, cal/gm	1000	60 mm Mortar Projectile:
Gas Volume, cc/gm	675	50% Inert, Velocity, ft/sec
Formation, cal/gm	245	Aluminum Fineness
Fusion, col/gm (3) Temperature, O	20.4	500-lb General Purpose Bombs;
Specific Heet: col/gm/°C (e)		
°c		Plate Thickness, inches
6	0.235	
30 60	0.258 0.282	1
50 90	0.202	134
120	0,337	11.2
		13,
Burning Rote: cm/sec		Bomb Drop Test:
Thermel Conductivity: (f)	,,	-
col/sec/cm/°C Density, gm/cc	б.2 <sup>4</sup> х 10 <sup>-4</sup> 2.406	77, 2000-1b Semi-Armon Siercing Bomb vs Concrete:
Coefficient of Expansion:		Max Safe Drop, ft
Linear, %/°C		500-lb General Purpose Bomb vs Concrete:
Volume, %/°C		Height, ft
		- Trials
Hardness, Mohs' Scale:	2.1	Unaffected
		Low Order
Young's Modulus:		High Order _
E', dynes/cm²		
E, Ib/inch <sup>2</sup>		1000-Ib General Purpose Bomb vs Concrete:
Density, gm/cc		
Commenter Comments that the state		Height, ft
Compressive Strength: Ib/inch <sup>2</sup>		Trials
······································		Unaffected
Vapor Pressure:		Low Order
°C mm Merci	Jry	High Order
195 2		
295 90		

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### Picric Acid

90 mm HE, M71 Projectile, Lat WC-91:	Glass Canas Stani (				
Density, gm/cc Charge Wt, Ib	Glass Cones Steei Cones Hole Volume Hole Depth				
Total No. of Fragments: For TNT	Color: Ye	llow			
For Subject HE <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	<b>Principal Uses:</b> Formerly projectile filler, now explosive admixture; and for the manufac use of Explosive D				
<b>Totul No. of Fragments:</b> For TNT For Subject HE	Method of Looding: P	resseå			
Fregment Velocity: ft/sec Ar 9 ft At 25½ ft Density, gm/cc	3 5 10 12	x 10 <sup>3</sup> 15 20 .61 1.64 Dry			
Blast (Relative to TNT):	Huzard Class (Quantity-Distance)	Class 9			
Air: Peak Pressure Impulse Energy	Compatibility Group Exudation	Group I None			
Air, Confined: Impulse					
Under Weter: Peak Pressure Impulse Energy					
Underground: Peak Pressure Impulse					
Energy					

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<b>`</b>					1	Merie Acid	L		1	MCP 706-177
.4	lubili	ty: grame	per 100	grome (S	<u>) of:</u> (g)	)				
	Mar	ter	Alc	obol	1	enzene	T	oluene	Etl	her
	°c	٤	°c	2	°c	٤	°c	٤	°c	ž
	00 00 00 00 00 00 00 00 00 00 00 00 00	0.85 1.17 1.88 2.98 4.53 7.1	0 25 0	4.9 5.9 12.0	8 6 8 o	~2 9.6 27.5 59	20 60	~ 13 ~30	20 34•7	~3 3.96
	Chloro	form	Etby1	acetate	tetr	rbon Vchloride	<u> Py</u> :	ridine	Acet	tone
	°c	ž	°c	٤	°c	Ł	°c	ž	<u>°c</u>	ž
	20 60	~2 ~6	20 30 40 50	42 50 58 69	20 60	~0.07 ~0.4	10 بن 50	24 37.5 58	20 30 40 50	125 137 164 208
	Met	hanol	Isop	ropyl ele	cohol	Propan	<b>01-</b> ].	Carbon d	lisulfide	
	°c	٤	°c		ž	<u>°c</u>	ž	<u>°c</u>	£	
	0 20 40 50	14 19 31 41	10 30 50		6.4 9.8 15.5	0 20 20 50	2.4 3.3 5.4 7.4	20 30	0.12 0.16	
Pr	eparati	ion: (Sum	mary Rep	ert of M	DRC, Div	8, Vcl I)				
	сене	+ Hg(NO <sub>3</sub> )	2			C6H5HENO3	+ HNO3		(	(1)
						с <sub>6</sub> н <sub>5</sub> но + ;	-		(	(2)
	C6H5N	10 + 21110 .				C6H5N2NO3	-		(	(3=)
	C5H5N	12110 <sub>3</sub> + Н20	) ——		>	с6н50н + 1	N <sub>2</sub> + HNO <sub>3</sub>		(	36)
	C6H5C	ж + нис <sub>3</sub>		NO2	>	о2исентон	+ н <sub>2</sub> 0		(	3c)
	с <sub>бн</sub> 5к	io oxidati	H lon and :	NO <sub>3</sub> rearrange	ment	°2NC6H4OH			(	4)
	°2nce	;сн + нло <sub>3</sub>	<u> </u>	110 <sub>2</sub>	>	(02N)2C6H	3 <sup>0н</sup> + н <sub>2</sub> 0			5)
						( <sup>.)</sup> 2 <sup>N</sup> ) <sub>3</sub> C6H	-		(	6)

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#### Picric Acid

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The two variables of greatest 'mportance in this process are nitric acid concentration and the effective concentration of benzene (i.e., benzene dissolved in the oxynitration solution). The optimal concentration of nitric acid is in the range 10.4 to 11.6 molar (or the equivalent of 50% to 55% by weight for pure acid). The acid concentration greatly influences the over all rate of reaction, below 10.4 molar the rate falls off repidly, while above 10.4 molar the rates of both the oxynitration reaction and various side reactions, such as direct nitration, increase rapidly. The range mentioned above seems, in general, to give the lowest proportion of neutral nitro-compounds to nitro-phenols with, at the same time, an adequate rate of organitration. The oxynitration must be fortified frequently, or, preferably, continuously with nitric acid. Strengths of nitric acid between 95% and 98% are best, due to the smaller increase in reaction volume than if weaker acid were used. The use of absolute nitric acid requires that its direct contact with liquid benzene be avoided.

The effective concentration of between is probably the most critical variable affecting the proportion of neutral nitro-compounds to nitrophenols and amounts of colored by-products. Saturation of the experimentation solution with between the undesirable and thus in batch processes slow between addition is preferable to the addition of it in one portion; in continuous processes where an excess of benzene is used the rate of agitation is important.

The concentration of mercuric nitrate catalyst does not appear to be a critical factor over a mainly wide range. Concentrations of 0.37 to 0.5 mole of mercuric nitrate per liter of oxynitratic, solution have been found to give satisfactory results in most cases.

A continuous process, known as the continuous solution process, works on the following cycle. The oxynitration solution is saturated with benuene by vigorous agitation with excess benzene at more tamperature, the saturated solution is separated from excess benzene and circulated through a heated coil; it is then cooled to room temperature the agitat i again, with benzene, which extracts the organic product and resaturates the oxynitration solution. In evaluating this process, the rate of formation of dinitrophenol per liter of reacting solution in the coil is determined; 70 gm of dinitrophenol per liter performance. The dinitrophenol is, of course, nitrated to pieric acid.

#### Origin:

Picric Acid was first prepared in 1771 by Woulff who found the reaction of nitric acid and indige yielded a dye. Hausmann isolated Picri Ar 1 in 1776 and studyed it further (Journal de physique 32, 165 (1786)). The proparation was studied by many chemists but in 1841 faurent established its identity (Ann chim phys IJI, 2, 221 (1941)). It was used as a yellow dye until Murpin, in 1995, proposed Ficri and its a cursting charge for high explosive shell (French Patent 167,512). The British adopted discribed as a military explosive in 1868 under the mane of lyddite and other nations soon began to use it as the first meltloaded night explosive. Mixtures of other explosiver and Picric Acid were developed until it was gradually replaced by TMT about 1900. Today Pic is Acid is used for the manufacture of Explosive D.

#### Destruction by Chemical Lecomposition:

Pieric Acid is decomposed by dissolving in 25 times its weight of a solution made from 1 part sodium hydroxide and 21 parts sodium sulfide ( $Ha_23^{-9}H_20$ ) in 200 parts of water. Some hydrogen sulfide and annonis are evolved.

### Picric .....

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#### References: 60

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(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, Part III - Mircellaneous <u>Sensitivity Tests</u>; <u>Performance Tests</u>, OSRD Report No. 5746, 27 December 1945.

(b) Ph. Naoum, Z ges Schitss-Sprengstoffw, pp. 181, 229, 267 (27 June 1932).

(c) D. P. MacDougall, Methods of Fnysical Testing, OSRD Report No. 803, 11 August 1942.

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M. D. Hurwitz, The Rate of Detonation of Various Compounds and Mixtures, OSRD Report No. 5611, 15 January 1945.

(e) International Critical Tables.

(f) E. Hutchinson, The Thermal Sensitiveness of Explosives. The Thermal Conductivity Explosive Materials, AC Report No. 2001, First Report, August 1942.

(g) Values taken from various sources in the open literature.

(h) Also see the following Picatinny Arsenal Technical Reports on Picric Acid:

<u>1</u>	2	3	4	٤	6	I	<u>8</u>	2
1651	132 582 1172 1352 1372	1383	694 764 874	65 425 1585	266 556 926 976 986 1446 1556	1347 1557	1118	15×9

<sup>60</sup>See Cootnote 1, page 10.

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31.

PIPE

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Composition: %		Molecular Weight:	310
70		Oxygen Belance:	
PEIN	81	CO. %	-74
Gulf Crown E Oil	19	CO %	- 31
	-/	Doneity: gm/cc Hend tam, ~d	1.35
		Molting Point: *C	
C/H Rotio		Freezing Point: *C	
Impact Sensitivity, 2 Kg Wt:		Boiling Point: "C	· · · · · · · · · · · · · · · · · · ·
Bureau of Mines Apparatus, cm Sample Wt 20 mg		Refrective Index, n2	
Picatinny Arsenal Apparatus, in.	11	-	
Sample Wt, mg	27	R <sup>D</sup>	
		n,	
Friction Pendulum Test:		Vocuum Stability Test:	
Steel Shoe Unaffect		cc/40 Hrs, at	
Fiber Shoe Unaffed	ted	90°C	. 10
Rifle Bullet Impact Test: Trials		- 100°C	0.48
%		120°C 16 hours	11+
Explasions 0		135°C	
Partials 0		150°C	
Burned O		200 Grcm Bomb Sond Test:	
Unoffricted 100		Sand, gm	41.6
Explosion Temperature: *C		Sensitivity te Initiation:	· · · · · · · · · · · · · · · · · · ·
Seconds, 0.1 (no cop used)		Minimum Detonating Charge, gm	
1		Mercury Fulminate	0.20*
5 Decomposes*		Lead Azide	0.20*
10		*Alternative initiating charge	
15			88 ·
20 *No value obtained.		Bellistic Morter, % THT:	
75°C International Heat Test:		Treuzi Test, % TNT:	
% Loss in 48 Hrs		Plate Deat Test: (a) Method	в
100°C Heat Tak:		Condition	Hand tamped
•••••	0.17	C :nfined	No
	0.00	Density, gm/cc	1.33
	None	Brisonce, % TNT	76
Explosion in 100 Hrs			
Flommobility Index:		Detsnetion Rate:     Confinement	None
		- Condition	Hand tamped
Hygroscopicity: % 30°C, 90% RH	0.02		hand tamped 1.0
		Charge Diometer, in.	
Velatility:		Density, gm/cc	1.37
		<ul> <li>Rate, meters/second</li> </ul>	7075

2

Shaped Charge Effectivaness, TNT = 100: ntation Test: 90 mm HE, M71 Projectile, Let WC-93: Glass Cones Steel Cones Density, ym/cc 1.33 **Hole Volume** Charge Wt, Ib 1.723 Hole Depth Total No. of Fregments; Color: 703 For TNT For Subject HE 519 Principal Uses: Plastic demolition explosive 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc 1.39 Charge Wt, Ib 0.735 Total No. of Fragm a di se Method of Londing: Hand tamped 514 For TNT 428 For Subject HE Looding Density: gm/ct 1.35 Freyment Velocity: ft/sec At 9 ft At 25½ ft Storage: Density, gm/cc Mathod Dry Class 9 Blast (Relative to THT): Hazard Class (Quantity-Distance) **Compatibility Group** Group I Peok Pressure Exudation Impulse Energy Origin: Air, Confined: PIPE, a mechanical mixture of PETN and Gulf Crown E Oil, was developed in the United States during World War II. Impulse Under Weter: \_\_\_\_\_\_ Peak Pressure References: 61 Impulse (a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part IIJ-Miscellaneous Sensitivity Tests; Performance Tests, OSRL Re-port No. 5746, 27 December 1945. Energy Un d: dergre Peak Pressure (b) S. Livingston, <u>Properties of Explosives</u> <u>RIPE, PIPE and PEP-3</u>, <u>Picatinny Arsenal Techni-</u> cal Report 1517, 24 April 1945. Impulse Energy Preparation: PIPE is manufactured by simple mechanical mixing of PETN in oil.

PIPE

filsee footnote 1, page 10.

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### Plumbatol

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Competition:		Molocular Weight:	291
96 Lead Nitrate	70	Oxygen Belence: CO <sub>2</sub> %	-5.4
INT	30	CO %	+9.3
		Density: gm/cc	
		Molting Point: "C	
C/H Rotio		Freezing Point: "C	
mpect <u>Senuitivity, 2 Kg Wt.</u> Bureau of Mines Apparatus, cm		Boiling Point: *C	
Sample Wt 20 mg	••	Refractive Index, na	
Picationy Arsenal Apparatus, in. Sample Wt, mg	13 22	ng	
		n <u>5</u>	
riction Pondulus: Test:		Vecuum Stebility Test:	
Steel Shoe		cc/40 Hrs, at	
Fiber Shoe		90°C	
Lifie Bullet Impoct Test: Trials		100°C	
96		120°C	
Explosions		133°C	
Partials		150 C	
Burned		200 Grem Bomb Send Test:	
Unaffected		Sand, gm	32.4
xplosiun Temperature: *C		Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, gm	
l 5 Decomposes 238		Mercury Fulminate	••
10		Lead Azide	0.20
15		Tetryi	0.^0
20		Bellistic Mortor, % TNT:	
5°C International Heat Test:		Trouzi Test, % TNT:	
% Loss in 48 Hrs		Plate Dent Test: Method	
00°C Heat Test:		Condition	
% Loss, 1st 48 Hrs		Confined	
% Loss, 2nd 48 Hrs		Density, gm/cc	
Explosion in 100 Hrs		Brisance, % TNT	
		Detonation Rate: (c)	<u></u>
emmebility Index:		Confinement	
lygroscopicity: %		Condition	
······································		Charge Diameter, in.	
'eletility:		Density, gm/cc	2.39
		Rate, meters/second	4350

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### Plumbetol

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Fragmontation Test:	Shaped Charge Effectiveness, TNT = 100:
90 mm HE, 547? Prejectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones (a) Hole Volume 114 Hole Depth 103
Total He, of Prognants: For TNT For Subject HF	Celer: Light yellow
3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib	Principal Users
Tatel No. of Fregments: For TNT For Subject HE	Method of Londing: Cast
	Looding Donaity: gm/cc
Pregment Velacity: ft/sec At 9 ft At 25½ ft Density, gm/cc	Storege: Method Dry
Blast (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9
Air: Peok Pressure Impulse Energy	Compatibility Group Group I Exudation
Air, Confined: Impulse	Origin: An explosive containing 70% lead nitrate and 50% TNT has been used in Belgium under the name of "Marcarite."
Peak Pressure Impulse Energy	References: <sup>62</sup> (a) Eastern Laboratory, du Pont, <u>Investi-</u> gation of Cavity Effect, Sec III, Variation of Cavity Effect with Explosive Corposition, NDRG
Underground: Poak Pressure Impulse Energy	Contract W-672-ORD-5723. (b) <u>Compets Dictionary of Applied Chem-</u> istry. Fourth Edition, Vol IV. Longmans, Green and Company, London - New York - Toronto, p. 464.
Preparation: Plumbatol is manufactured by simple mechanical mixing of lead nitrate in molten TNT.	

62See footnote 1, page 10.

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### PLX (Liquid)

Vac.384

Competition:			Molocular Weight:	<u>100</u> 61	<u>95/5</u> 61
96 Mitar and the ne	100	* 95	Oxygen Belence:		
Nitromethane			CO, %	- 39	-48
Sthylenediamine	 /*	5	CO %	-13	-21
*The mixture 95/5 Nitr is designated PLX (fo sive). See note under	or Pication	w Liquid Explo-	Density: gm/cc	1.14	1.12
			Molting Point: *C	-29	
C/H Ratio			Freezing Point: "C		
Impact Sensitivity, 2 Kg W Bureau of Mines Appara		<u>100 95/5</u> 100+ 100+	Bailing Point: "C	101	
Sample Wt 20 mg	aus, cm	100+ 100+	Refrective Index. no		
Picatinny Arsenal Appar	atus, in.	20 20	ng		
Sample Wt, mg		20 20	20		
Friction Pandulum Tast:					
Steel Shoe	11.	affected	Vocuum Stability Test: cc/40 Hrs, at		
Fiber Shoe		affected	90°C		
			100°C		
Rifle Bullet Immect Test: 3	0 Trials	5 Trials	120°C		
	%	\$	135°C		
Explosions	Õ	<b>\$</b> .;	150°C		
Partials	0	0			
Burned	U I	c/	200 Grant Bomb Sond To		<u>95/5</u>
Unaffected	100	100	Sand, gm	8.1	50.6
Explosion Temperature:	•c	°C	Sensitivity to Incitiation:		
Seconds, 0.1	100	<u>95/5</u>	Minimum Detonoting	Charge, gm	
1			Mercury Fulminate	1	
5	430	430	Lead Azide		
10			Tetryl		
15					
20			Sellistic Mortor, % TN		
75°C International Heat Te			Trouzi Tosi, % PA	127	
% Loss in 48 Hrs			Plate Dent Test: Method		
100°C Heat Test:			Condition		
% Loss, 1st 48 Hrs			Confined		
% Loss, 2nd 48 Hrs			Density, gm/cc		
Explosion in 100 Hrs			Brisance, % TNT		
			Detonation Rate:	1/32"*	1/32"*
Flammebility Index:			Confinement	Gless	Glass
			Condition	Liguid	Liquid
Hygrescopicity: %			Charge Diameter, in.	1.25	0.94
		······	Density, gm/cc	1.14	1.12
Velatility:			* Tube sell thicknes	6210	6165

a construction of the second 
Condition ocomposition Equation: Oxygen, atoms/sec (Z/sec) (ð) Nitromethane 1014.0 Kitromethane -D Tetryl, gm **56.**0 Heat, kilocalorie/mole (ΔH, kcol/mol) Temperature Rcnge, °C Wax, in. for 50% Detonation 380-430 Wax, gm Density, gm/cc Phase Gaseous (a) 2830 Next of: Armer Plate Impact Test: Combustion, col/gm Explosion, cal/gm 50% Inert, Velocity, ft/sec **60** . Gas Volume, cc/gm - 348 Formation, col/gm Aluminum Fineness Fusion, col/gm Veporisation, cal/gm 149 500-lb General Purpose Bo cific Heat: col/gm/\*C (b)  $C_{p} = 0.4209 - 0.00076t + 0.0000061t^{2}$ for 15°C to 70°C Plate Thickness, inches 1 11/4 11/2 1% ming Rate: 8. cm/sec **Bomb Drop Test:** Thermal Conductivity: cal/sec/cm/\*C T7, 2000-lb Sami-Armer-Planck in Be mb vs Co Max Safe Drop, ft Coefficient of Exps Linear, %/\*C nsien : 500-16 General Propose Bamb vs Concrete: Volume, %/\*C Height, ft Trials Herdness, Mohs' Scele: Unaffected Low Order Young's Medulus: High Order E', dynes/cm² E, Ib/inch<sup>a</sup> 1000-Ib General Purpose Be b vs Concre Density, gm/cc Height, ft Compressive Strength: Ib/inch<sup>2</sup> Trials Unaffectea Vapor Pressure: "C Low Order (c) mm Mercury High Order 258 444 **70** 85

PLX (Liquid)

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Carlor States

Fragment lien Test:	Sheped Charge Effectiveness,	TNT == 100:	
90 mm HE, M71 Projecti/e, Let WC-91:	Glass Cones	Steel Con	85
Density, gm/cc	Hole Volume		
Charge Wt, Ib	Hole Depth		
Total No. of Fragmints:	Color:	Light yel	low
For TNT			
For Subject HE	Principal Uses: Minefiel	d clearing	
3 inch HE, M42A7 Projectile, Let KC-5:			
Desity, gm/cr.		*	
Charge Wt, It			
Total No. of Progmants:	Mathed of Loading:	Pump	ing
For TNT	-	•	
For Subject HE		100	2
	Loading Density: gm/cc	1.14	2
Fragment Velocity: ft/sec			_
At 9 ft At 25½ ft			
	Storege:		
Density, gm/cc			
	Storage: Mathod Components s mixed only w		
	Method Components s	hen ready	
Density, gm/cc Blast (Relative to TNT):	Method Components s mixed only w Hazard Class (Quantity-Dis	hen ready	
Density, gm/cc Blast (Relative to TNT): Air:	Method Components s mixed only w	hen ready	
Density, gm/cc Blast (Reletive to TNT): Air: Peak Pressure	Method Components s mixed only w Hazard Class (Quantity-Dis	hen ready	
Density, gm/cc Blast (Relative to TNT): Air: Peok Pressure Impulse	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group	hen ready	
Density, gm/cc Blast (Relative to TNT): Air: Peak Pressure Impulse Energy	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group Exudation	hen ready tonce)	
Density, gm/cc liest (Reletive to TNT): Air: Peak Pressure Impulse Energy Air, C., Smod:	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group	hen ready	
Density, gm/cc Blast (Relative to TNT): Air: Peak Pressure Impulse Energy	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group Exudation <u>Minimum Propagating</u> <u>Thickness, in:</u>	tonce)	
Density, gm/cc Blast (Reletive to TNT): Air: Peak Pressure Impulse Energy Air, (	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group Exudation <u>Minimum Propagating</u> <u>Thickness, in:</u> <u>Viscosity, centipoises:</u>	tonce)	to
Density, gm/cc Blast (Relative to TNT): Air: Peok Pressure Impulse Energy Air, (	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group Exudation <u>Minimum Propagating</u> <u>Thickness, in:</u> <u>Viscosity, centipoises:</u> Temp, 10 <sup>0</sup> C	tonce) 100 0.5 (*) 0.748	to
Density, gm/cc Blast (Relative to TNT): Air: Peok Pressure Impulse Energy Air, (	Method       Components s         mixed only w         Hazard Class (Quantity-Dist         Compatibility Group         Exudation         Minimum Propagating         Thickness, in:         Viscosity, centipoises:         Temp, 10°C         25°C	100 0.5 (*) 0.748 0.625	to
Density, gm/cc Blast (Relative to TNT): Air: Peak Pressure Impulse Energy Air, C., Sinod: Impulse Under Weter: Peak Pressure	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group Exudation <u>Minimum Propagating</u> Thickness, in: <u>Viscosity, centipolses:</u> Tem;, 10°C 25°C 40°C	100 0.748 0.625 0.533	to
Density, gm/cc Blast (Relative to TNT): Air: Peak Pressure Impulse Energy Air, ( Sined: Impulse Under Water: Peak Pressure Impulse Energy	Method       Components s         mixed only w         Hazard Class (Quantity-Dist         Compatibility Group         Exudation         Minimum Propagating         Thickness, in:         Viscosity, centipoises:         Temp, 10°C         25°C	100 0.748 0.625 0.533	to
Density, gm/cc Heat (Relative to TNT): Air: Peak Pressure Impulse Energy Air, ( Gined: Impulse Under Weter: Peak Pressure Impulse Energy Underground:	Method       Components s         mixed only w         Hazard Class (Quantity-Dist         Compatibility Group         Exudation         Minimum Propagating         Thickness, in:         Viscosity, centipoises:         Temp, 10°C         25°C         40°C         Compatibility with Metal	100 0.5 (*) 0.748 0.625 0.533 s:	to
Density, gm/cc Blast (Reletive to TNT): Air: Peak Pressure Impulse Energy Air, C. Sined: Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure	Method Components s mixed only w Hazard Class (Quantity-Dis Compatibility Group Exudation <u>Minimum Propagating</u> Thickness, in: <u>Viscosity, centipolses:</u> Tem;, 10°C 25°C 40°C	100 100 0.5 (*) 0.748 0.625 0.533 s: steel and	to
Density, gm/cc Blast (Relative to TNT): Air: Peak Pressure Impulse Energy Aie, ( - Sined: Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse	Method       Components s         mixed only w         Hazard Class (Quantity-Dist         Compatibility Group         Exudation         Minimum Propagating Thickness, in:         Viscosity, centipoises:         Temp, 10°C 25°C 40°C         Compatibility with Metal Stainless steel, mild	tonce) 100 0.5 (*) 0.748 0.625 0.533 s: steel and	to
Density, gm/cc Blast (Reletive to TNT): Air: Peak Pressure Impulse Energy Air, C. Sined: Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure	Method       Components s         mixed only w         Hazard Class (Quantity-Dist         Compatibility Group         Exudation         Minimum Propagating Thickness, in:         Viscosity, centipoises:         Temp, 10°C 25°C 40°C         Compatibility with Metal Stainless steel, mild	tonce) 100 0.5 (*) 0.748 0.625 0.533 s: steel and	to
Density, gm/cc last (Relative to TNT): Air: Peak Pressure Impulse Energy Air, ( Maed: Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse	Method       Components s         mixed only w         Hazard Class (Quantity-Dist         Compatibility Group         Exudation         Minimum Propagating Thickness, in:         Viscosity, centipoises:         Temp, 10°C 25°C 40°C         Compatibility with Metal Stainless steel, mild	tonce) 100 0.5 (*) 0.748 0.625 0.533 s: steel and	to

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### PLK (Liquid)

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#### Origin:

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Nitromethene has been known since 1872 (Kolbe, J prakt Cham (2) 5, 427 (1872), but was available only as a laboratory product until it appeared as an industrial chemical in 1940. A number of patents have been issued for nitromethene produced as a by-product of the titra-tion of propene (U. S. Patent 1,967,667 (1934); British Patent 7 3,707 (1937); and Canadian Patent 371,007 (1938).

The development of nitromethane liquid explosives was based on information that nitro-methane is sensitized to initiation and propagation of defonation by the addition of various amines. This study made at Picatinny Arsenal in 1945 indicated that mixtures of nitromethane with 5% of ethylenediamine, n-butyl-mine, or morpholine ghowed considerable promise for ap-plication in mine-field clearance (L. H. Kriksen and J. W. Howen, PATR No. 1965, 17 September 1945).

#### References:63

63See footnote 1, page 10.

(a) D. E. Holcomb and C. F. Dorsey, "Shermodynamic Properties of Nitroparaffine;" Ind Eng: Chem 41, 2788 (1949).

(b) J. W. Williams, "A Study of the Physical Properties of Nitromethane," J Am Chem Soc <u>47</u>, 2644 (1925).

(c) L. Medard, "Explosive Properties of Nitromethane," Mem poudr 33, 125 (1951).

(d) T. L. Cottrell, T. E. Graham and T. J. deid, "The Thermal Decomposition of Mitro-methanes," Transactions of the Farafay Societ, 47, 584 (1951).

(e) F. Bellinger, H. B. Friedman, W. H. Bauer, J. W. Eastes and W. C. Bull, "Chemical Propellants: Stability of Mononitromethane," Ind Engr Chem 40, 1320 (1948).

(f) Also see the following Picatinny Arsenal Technical Reports on Nitromethane:

<u>o</u>	ĩ	3	5	<u>6</u>	Ĩ	8	2
1660	1681 1831	2113	<b>15</b> 65 -	2016	1747	1708	1619

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#### Potassium Dinitrobensfurozan (KDNEBP)

Co. ypesthiait:	Melecular Weight: (KCGH4H4OG)	225
и с 27.3 н 0.4 N 21.2	Oxygen Belence: CO, % CO %	-60 -18
	Density: gm/cc	2.21
K 14.8	Molting Point: "C Explodes	210
C/H Ratio 0.426	Freening Point: *C	
Suspect Sensitivity, 2 Kg Wt:	Solling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 3; (1 1b vt) 6 Sample Wt, mg 7	Refrective Index, no no no	
Frietion Pandatum Test: Steel Shoe Explodes Fiber Shoe Explodes	Vectore Stability Test: cc/40 Hrs, at 90°C 100°C	
Rifle Bullet impost Test: Trials % Explosions Partials	120°C 120°C 135°C 150°C	
Burned Unaffected	200 Gram Band Sand Text: Sand, gm Black powler, Duse, 9-5	43.6
Explected Temperature: *C Secands, 0.1 (no cop used) ~- 1 5 250 10 15	Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate 0-30 Lead Azide Tetryl	0.20 0.10
	Belliutic Marter, % THT:	
73°C Internetional flast Test:	Trauni Yost, % THT:	l
% Loss in 48 Hrz	Plate Basic Teat: Method	
100°C Heat Test:         0.03           % Loss, 1st 48 Hrs         0.03           % Loss, 2nd 48 Hrs         0.05           Explasion in 100 Hrs         None	Condition Confined Density, gm/cc Brisonce, % TNT	
Flormability index:	Datemation Rate: Confissement	
Mygressepicity: % 30°C, 75% RH 0.11 30°C, 90% PH 0.27	Condition Charge Dierseter, in.	
V.Actility:	Density, gm/cc Rate, misters/second	

Bessier Sensitivity Test: Condition Tetryl, gm Wax, in. for 50% Detonation Wax, gm Density, gm/cc	•,	Oxygen, etome/sec (Z/sec)
Wax, in. for 50% Detonation Wax, gm	•、	i (7/902)
Wax, gm		
		Heat, kilocolorie/mole (AH, kcal/mol)
Density, am/cc		Tomperature Range, *C
		Phase
Meet of: Combustion, col/gm	2209	Anner Plata Impost Test:
Explosion, col/gm	725	· · · · · · · · · · · · · · · · · · ·
Gas Volume, cc/gm	604	50% Inert, Velocity, ft/sec
Formation, col/gm	1. S.	Aluminum Fineness
Fusion, cal/gm		
	<u> </u>	500-Ib General Purpose Bamba:
Speallie Heat: col/gm/*C (b)		Plate Thickness, inches
-50	0.217	
0	0.217	114
25	0.217	1%
50	0.217	
Burning Roto: cm/sec		
	<u></u>	Bomb Drop Tast:
Thermal Conductivity: col/sec/cm/*C		17, 2000-Ib Sami-Armer-Placeing Bamb vs Cane
Caefficient of Expansion:		Max Safe Drap, ft
Linear, %/*C		500-th General Purpose Bomb vs Constate:
Volume, %/*C		Height, ft
		Triots
Hardness, Mohe' Scale:		Unaffected
Young's Medulus:		Low Order
•		High Order
E', dynes/cm²		
E, Ib/inch*		1000-lb General Purpese Bamb vs Concrete:
Density, gm/cc		
Parmanente Care at the Martin		Height, ft
Compressive Strength: Ib/inch <sup>#</sup>		Triols
		Unaffected
Vapor Pressure:		Low Order
°د mm Mercury		High Order

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#### ALCP 706-177

### Potassium Dinitrobeazfuroxan (KDNBF)

Fragmentation Test:	Shaped Charge Effectiveness, TNT = 100:
98 unin ME, M71 Projestila, Lat WC-91: Density, gm/cc Charge Wt, Ib	Glass Cones Steel Cones Hole Volume Hole Depth
Total No. of Fragments: For TNT	Celer: Orange to brown
For Subject HE <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Chorge Wt, Ib	Principei Uess: Primary explosive
Tetel No. of Fregments: For TNT For Subject HE	Mothed of Looding: Pressed
Fragment Velecity: ft/sec At 9 ft At 25½ ft Dersity, gm/cc	Leading Density: gm/cc psi x 10 <sup>3</sup> 10 20 30 40 80 1.63 1.77 1.81 1.86 1.98 Storage: Method Wet
Blast (Relative to TNT):	Hozard Class (Quontity-Distance) Class 9
Air: Peok Pressure Impulse Energy	Compatibility Group Group M (wet) Exudation
Air, Cenfined: Impulse	Solubility in Wat, gm/100 gm solvent, at: 30°C 0.245
Under Weter: Peak Pressure Impulse Energy	Stab Sensitivity:           Density         Firing Point (Inch-ounces)           gm/cc         05         50%         100%           1.63         73         79         84
Underground: Peak Pressure Impulse Energy	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
	Activation Energy:       kcal/moi       B2.6       Induction-Period. sec       0.5-10
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Potassium Dinitrobenzfuroman (KDMBF)

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### Preparation of Potassium Salt of 4,6-dinitrobensfurozan: (a)

Benifuronan, made by the reaction of ortho-nitroaniline case alkaline sodium hypochlorite, was discolved in 6 parts of 96% sulfuric acid and nitrated at  $j^{\circ}$ -20°C with a 4 to 1 sulfuricnitric acid mixture. The salt was prepared by neutralization of the 4,6-dinitrobenzfuronan with potassium bicarbonate followed by recrystallization from hot water. The product forms in small golden orange plates which explode at 210°C.

#### Origin:

The potassium salt of 4,6-dinitrobenzfurozan was first prepared in 1899 by von P. Drost (Ann 307, 56 (1899)).

### Haferences: 64

(a) R. J. Gaughran, J. P. Picard and J. V. R. Kaufman, "Catribution to the Chemistry of Bensfuronum Derivatives," J Am Chem Soc 76, 2233 (1954).

(b) C. Lenchitz, Jce Calorimeter Determination of Enthalpy and Specific Heat of Eleven Organometallic Compounds, PATE No. 2224, November 1955.

(c) Also see the following Picatinny Arsenal Technical Reports on Potassium Dinitrobenaforoman:

2	3	<u>6</u>	2
2.22	2093	2146	2179

64see footnote 1, page 10.

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PTX-1

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Compacition:		Mulecrier Weight:	252
%		Ozver "elence:	· · · · ·
RDK	30		-45
Tetryl	50	<u>٩ ( ) , 9 ( ) , 9 ( </u>	- 9
THT	20	· Density: gm/cc	1.68
	· · · · · ·	Moi - Point: 'C Eutectic	67
C/H Ratio		Freezing Point: "C	
impost Sensitivity, 2 Kg Wt:	44	Bailing Paint: *C	
Sursou of Mines Apporatus, cm Sample Wt 20 mg	44	Refrective Index, no.	
Picatinny Arsenal Apparatus, in. Sample Wt, mg		ang a	
		n	
Fristian Pandulum Test:		Vocuum Stability Test:	
Steel Shoe		cc/40 Hrs, at 90°C	
Fiber Shoe		- 100°C	3.0
tifle Bullet Impact Test: Trials		120°C	<b>J</b> , C
<b>5</b>		135°C	
Explosions 20 Partials 20		150°C	:
Burned 0		200 Gram Bomb Sind Test:	
Unaffected 60		Sand, gm	54.8
Englacion Temperature: *C	<u>,</u>	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, gm	
<u>,</u> 1		Mercury Fulminote	0.23*
		Lead Azide	0.22*
10		*Alternative initiating charges.	
15 20		Ballistic Morter, % TNT: (a)	132
		Treuzi Test, % TNT:	
75°C International Heat Test: % Lass in 48 Hrs		Plate Dent Test: (b)	
		Method	В
IGB'C Heat Test:	·····	· Condition	Cast
% Loss, 1st 48 Hrs		Confined	No
% Loss, 2nd 48 Hrs		Density, gm/cc	1.68
Explosion in 100 Hrs		Brisance, % TNT	127
		- Detenation Rate:	
Planmability Indat:		Confinement	None.
Hygressepicity: %		Condition	Cast
30°C, 90% RH, 15 days	0.00	Charge Diameter, in. — Density, gm/cc	1.0 1.64

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PTX-1

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Fregmentation Test:		Shaped Charge Effectiveness, TNT = 1	1 <b>00</b> 1
90 mm HE, M75 Projectile, Let WC-91:		Glass Cones Steel	Consis
Density, gm/cc	1.64	Hole Volume	
Charge Wt, Ib	2.190	Hole Depth	
Total No. of Fragments:		Celer:	······································
For TNT	703		
For Subject HE	999	Principel Uses: Land mines and de	molition
3 inch HE, M42A1 Projectile, Let KC-5:		charges	
Density, gm/cc	1.63		
Charge Wt, Ib	0.864		
Total No. of Fragments:		Mathed of Looding:	Cast
For TNT	514		
For Subject HE	685	Looding Density: gm/cc	1.68
Frequent Velocity: ft/sec			
At 9 ft At 25½ ft	2690 2460	Storege:	
Density, gm/cc	1.64	Method	Dry
Blast (Relative to TNIT):		Hazard Class (Quantity-Distance)	Class 9
Air:	(d)	Compatibility Group	Group I
Peak Pressure	111	-	
Impulse	109	Exudation Ra	udes at 65°C
Energy			<u></u>
Air, Confined:		Preparation:	-
Impulse		The ternary explosive system RDK, tetryl and TNT is prepared	
Under Water:		appropriate weight of water-wet	RDE to a tetry
Peak Pressure		tol (40/60) previously melted i	n a steam-
Impulse		jacketed melt kettle. Heating are continued until all the wat	
Energy		and the mixture is uniform in c	cuposition.
11- Anno 11- 11-		PTX-1 is also prepared by addin Composition B.	g tetryl to RDA
Underprovind: Peak Pressure			
Impulse		Compatibility with Metals:	
Energy		Dry: Aluminum, mild steel n	ot affected.
Booster Sensitivity Test: (c)		Wet: Aluminum, mild steel n	ot effected.
Condition Pros	••••	1	
Tetryl, gm 10 Wax, in. for 50% Detonation 1.	0 100 94 1.82		
	61 1.68		

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PTX-1

#### Origin:

The possibility of employing ternary mixtures to obtain explosives having greater power and higher brisance than binary mixtures was suggested by the analysis of Russian 76 mm, armor piercing high explosive rounds (PATR No. 1311, 17 July 1943). The Russian type ternary explosives, based on the composition and laboratory studies of such mixtures, were indicated to be effective pressed fillers. In conducting a preliminary study of <u>castable ternary</u> explosive mixtures suggested by the Russian fillers, a mixture consisting of RUX/tetryl/TNT, designated FTX-1 was developed which had explosive and physical properties offering considerable advantage for military applications (PATR No. 1350, 27 October 1943; and 1379, 11 January 1944).

A PTX-3 composition, prepared by the addition of Haleite to 40/60 tetrytol, also offered promise but limited to applications where the charge would not be required to withstand storage at  $65^{\circ}C$  without evudation.

### References: 65

(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, Part III - Miscellaneous Sensitivity Tests; <u>Performance Tests</u>, OSED Report No. 5746, 27 December 1945.

(b) D. P. MacDougall, Methods of Physical Testing, OSRD Report Ko. (03, 11 Augura 1942.

(c) L. C. Smith and S. R. Walton, <u>A Consideration of RDE/Wax Mixtures as a Substitute for</u> Tetryl in Boostors, NOL Memo 10,303, 15 June 1949.

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(d) W. R. Tomlinson, Jr., <u>Blast Effects of Bomb Explosives</u>, PA Tech Div Lecture, 9 April 1948.

(e) Also see the following Picatinny Arsenal Technical Reports on PTX-1:

<u>0</u>	2	3	<u>6</u>	I	2
1530	1402	1623	1466 1506	1437	1379 1429 1469

65see footnote 1, page 10,

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PTX-2

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Composition: %			Melecular Weight:	244	243
RDI	hh - 41		Oxygen Pelesce:		
I. LAK	44 - 47		CO <sub>2</sub> %	-33	-36
PEIN	28 - 26		CO %	- 3	- 4
THT	28 - 33		Density: gm/cc		1.70
			Mailing Point: *C	Butectie	75
C/H Ratio			Freezing Point: *C		
Import Sanoliivity		35	Builing Point: *C		
Sample Wt 2	nol Apparatus, in.	ענ	Refrective Index, nº nº nº		
Friction Pendulus	a Test:		Vecuum Stability Test:		
Steel Shoe Fiber Shoe		Crackles	cc/40 Hrs, ot 90°C		
			100°C		2.6
Rille Bullet Impo	et Test: Trials		120°C		11+
	960 60		135°C		
Explosions			150°C		
Portiols	0			<u></u>	
Burned	0		200 Gram Bomb Sand Tost:		-
Unoffected	40		Sond, gm		
Exploiton Tampo	•elure: •C		Sensitivity to Initiation:		
Seconds, 0.1 (	no cap used)		Minimum Detonating Ch	arge, gm	
2			Mercury Fulminate		0.21
5			Leod Azide		0.00
10			Tetryl		0.00
15 20			Ballistic Morter, % TNT:	(.)	138
			Treusi Test, % TNT:		
75°C Internation			Plate Dent Test:	(b)	
% Loss in 48	F173		Method	• •	в
IOO'C Heat Test					Cast
% Loss, 1st 4			Confined		No
% Loss, 1st 4			Density, gm/cc		1.71
			Brisonce, % TNT		141
Explosion in 10					
Flammability Ind					Name
					None
	6		Condition Charge Diameter, in.		Cast 1.0
Hvereeenichty: 9			i unarae Diameter, in.		T+0
30°C, 90%	RH, 15 days	0.00	- Density, gm/cc		1.70

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PTX-2

Fregmentation Test:		Shaped Charge Effectiveness, THT = 10	<b>10:</b>
99 mm HE, M71 Projectile, Let WC-91:		Glass Cones Steel C	ionez
Density, gm/cc	1.68	Hole Volume 🛛 ~ 1.30	
Charge Wt, 85	2.226	Hole Dapth	
Total No. of Fragments:		Celer:	
For TNT	703		
For Subject HE	1128	Principal Uses: Shaped charges	
3 inch HE. M42A1 Projectile, Lot KC-5:		Fragmentation ch	irges
Density, gm/cc	1.70		
	0.897		
Charge Wt, Ib	0.091		
Total No. of Fragmants:		Method of Locding:	Cast
For TNT	514		
For Subject HE	750		
		Loading Density: gm/cc	1.70
Frequent Velocity: ft/sec			- T
At 9 ft	3020 2850		
At 251/2 ft		Storage:	
Density, gm/cc	1.70	Me thad	~
		MA INGO	Dry
Einst (Relative to TiviT):		Hazard Class (Quantity-Distance)	Class 9
Air: Pack Pressure	(4)	Compatibility Group	Group I
	113	Exuderion	None at 65°C
Impulse	113		
Energy	*-		
Air, Confined:		Preparation:	
Impulse		The ternary explosive system RDX, PETN and TMT is prepared by	
Under Water:		appropriate weight of water-wet	
Peak Pressure		tolite (30/70) previously welte	d in a steam-
Impulse		jacketed melt kettle. Heating	
Energy		are continued until all the wat and the mixture is uniform in c	
		PTX-2 is also prepared by adding	
Underground:		PETM to RDX Composition 3.	
Peak Pressure		Competibility with Metals:	
Impulse			
Energy		Dry: Aluminum, mild steel no	JU HIICCURA.
Booster Sensitivity Test: (c)		<u>Wet:</u> Aluminum not affected.	
Condition Pres			
Tetryl, gm 10			
Wax, in. for 50% Detonation 1.	87 2.32		
Density, gu/cc 1.	70 1.61		

#### <u>PTX-2</u>

#### Origin:

The possibility of employing ternary mixtures to obtain explosives having greater power and higher brisance than binary mixtures was suggested by the analysis of Russian 76 mm, armorpiercin; high explosive rounds (PATR Ho. 1311, 17 July 1543). The Russian type ternary explosives, based on the composition and laboratory studies of such mixtures, were indicated to be effective pressed fillers. In conducting a preliminary study of castable ternary explosive mixtures suggested by the Russian fillers, a mixture consisting of RDM/PETM/THT, designated PTX-2 was developed which had explosive and physical properties offering considerable advantage for military applications (FATR Ho. 1360, 27 October 1943; and 1379, 11 January 1944).

A PTX-4 composition, prepared by the addition of Haleite to 30/70 Pentolite, also offered promise but because of border-line stability in accelerated stability tests, PTI-4 must be proven by long term storage to be acceptable for use in standard ammunition.

#### References; 66

(a) L. C. Smith and E. G. Ryster, <u>Physical Testing of Explosives</u>, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSED Report No. 5746, 27 December 1945.

(b) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(3) L. C. Smith and S. R. Walton, <u>A Consideration of RDK/Wax Mixtures as a Substitute for</u> Tetryl in Boosters, NOL Meno 10,303, 15 June 1949.

(d) W. R. Tomlinson, Jr., <u>Blast Effects of Bomb Explosives</u>, FA Tech Div Lecture, 9 April 1948.

(e) Also see the following Picatinny Arsenal Technical Reports on PTX-2:

<u>o</u>	2	3	4	2	<u>6</u>	<u>8</u>	2
1530	1482	1483 1623	1414	1445	1466	1838	1379 1429

66See footnote 1, page 10.

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### PVA-4

				1 M
Composition: %		Molecular Weight:	217	
	~ <sup>1</sup>	Onygen Belence:		
RDX	90	CO. %	-37 -10	
Polyvinyl Acetate	8	<u> </u>		
Dibutylphthalate	2	Deneliy: gm/cc Prossed	1.60	
		Sortaning Point: ºC	92	
C/H Ratio		Freezing Point: "C		
Impost Sanoltivity, 2 Kg Wt:		Boiling Point: *C		
Bureau of Mines Apparatus, cm Sample Wt 20 mg	39	Refrective lades, no		
Picatinny Arsenal Apparatus, in.	9			
Sample Wt, mg	13	n <u>ä</u>		
		n <mark>e</mark>		_
Friction Pondulum Test:		Vocuum Stability Test:		
	uckles	cc/40 Hrs, at		
Fiber Shoe Uni	ffected	90°C	0.45	
Rifle Bullet Impact Test: 5Trick *		120°C	0.88	
Stolosions 20		135°C	••	
		150°C	11+	
Partials 0				_
Burned 60 Unoffected 20		200 Gram Bamb Sand Test: Sand, gm	58.5	
#100 trials at -46°C - Unaffected				-1(
Explosion Temperature: *C		Sensitivity to Initiation:		
Seconds, 0.1 (no cop used)		Minimum Detonating Charge, gm		
1 330 5 Decomposes 375		Mercury Fulminate	0.22	
10 265		Tetryl		
15				
20		Ballistic Mortor, % TNT:		-
75°C International Heat Tast:		Treuxi Test, % TNT:		
% Loss in 48 Hrs		Plate Dent Test: Method		
		- Condition		
100°C Heat Test:		Confined		
% Loss, 1st 48 Hrs	0.10	Density, grn/cc		
% Loss, 2nd 48 Hrs	0.06	Brisance, % TNT		
Explosion in 100 Hrs	None			-1
Flommobility Index:		Detenstion Rote:     Confinement	None	
		Condition	Cas+	
Hygressepicity: % 30°C, 90% RH	0.20	Charge Diameter, in.	1.0	
		- Density, gm/cc	1.60	
Veletility: 55°C, vacuo, 6 hrs	0.03	Rate, meters/second	7910	

$\mathbf{\mathcal{T}}$		PVA-4	AMCP 706-17
	Progmontustum Test:	Shaped Charge Effectives	
	90 mm HE, M71 Projectile, Lat WC-91:	Gione Co	nes Steel Cones
	Density, gm/cc	Hole Volume	
	Charge W1, Ib	ticle Depth	
	Total bio. of Progmants:	Calar	White
ļ	For TNT		
·	For Subject HE	Principal Vess:	Demolition charges
	3 inch Hil, M42A1 Projectile, Let KC-5:		
	Density, gm/cc		,
· · [	Charge Wt, Ib		
	Total No. of Frequents:	Mathed of Loading:	Pressed or extruded
	For TNT		
÷	For Subject ME	Looding Density: gm/cc	1.60
i t	Fregment Velocity: ft/sec		
	At 9 ft		
	At 25% ft	Storege:	
	Density, gm/cc	Method	Dry
- , [	Siest (Relative to TNT):	Hazard Class (Quantity	-Distance) Class 9
$\mathcal{I}$	Alex	Compatibility Group	Grow T
	Padk Presure	Company Goop	Group I
	Impulse	Exudation	None at 71°C
	Energy		
Ī	Air, Canfined:	Plasticity:	
	Impulse	-40°c	
	Under Wateri		Cracked
	Pack Pressure	25°c	0.3
	Impulse		
	Energy		
	Undergrænnd: Pack Pressure		
	Impulse		
1	Energy		
	r		
		1	
		1	

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#### AMCP 706-177

PVA-4

### Preparation:

Explosive PVA-4, a semi-plastic composition of Canadian origin, consists of 90% RDX, 8% polyvinyl acetate and 2% dibutylphthalate (DEP). This formulation was developed by Dr. Suthurland of Shewingan Chemicals, Ltd. In evaluating various types of polyvinyl acetate commercially available in the United States, a type obtained from Union Carbide and Carbon, under the industrial maned or designation "AYAT" was the mort promising coating for RDX in the proportions RDX/FVA(AYAT)/DEP 92/6/2.

A practical method of preparing this composition was by the addition of a solution of the coating agent to an aqueous RDK slurry. Based on the quality of the product and the pellet densities obtained, a procedure of adding an acctone solution of FVA + DEP to a hot water slurry of RDK, under agitation, was adopted as standard.

#### Beferences: 67

(a) See the following Picatinny Arsenal Technical Reports on PVA-4: 1532 and 1634.

### 67see footnote 1, page 10.

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the survey

### PVN (Polyvinyl Nitrate)

Compacition:		Molecular Weight: (C2H	3 <sup>RC</sup> 3) 2	(89
% C 227		Onygen Belence:		
-		CC. % CO %		-49 - 9
H 3.4 (H <sub>2</sub> C-CH-ORO2	<b>`</b>			• 7
N 15.6	'n	Density: gm/cc		
o 54		Mailting Point: "C (So	ft Pb)	50
C/H Ratio 0.203		Freezing Point: *C		
Impost Sanshivity, 2 Kg Wt:	14.86%N	Boiling Point: *C		
Bureau of Mines Apparatus, cm Sample Wt 20 mg	<b>*•</b>	Refrective Index, no		
Picatinny Arsenal Apparatus, in.	h,	ng		
Sample Wt, mg		n		
Friction Pandajan Test:		Vecuum Stability Test:		
	Crackles	cc/40 Hrs, at		
Fiber Shoe	Unaffected	90°C	16 hours	u
Rifle Bally: Impact Test: Trials		120°C	16 hours	ii ii
96		120 C	10 10010	-
Explosions		150°C		
Portiols				
Burned		200 Gram Bomb Sand Test: Sand, gm		hg
Unaffected				
Explosion Temperature: *C		Sensitivity to Initiation: Minimum Detonating Ch		
Seconds, 0.1 (no cap used)		Mercury Fulminate	ange, gan	
5 265		Lead Azide		
10		Tetryl		
15				
20		Bailistic Morter, % TNT: Trauel Test, % TNT:		
75°C International Heat Test:		Plate Deat Test:		
% Lose in 48 Hrs		Method		
188°C Heat Test:		Condition		
% Loss, 1st 48 Hirs	1.9	Confined		
% Loss, 2nd 48 Hrs	2,1	Density, gm/cc		
Explosion in 100 Hrs	None	Brisance, % TNT		واغدا المتعادلة
		Confinement		
Mammability Jades:				
	0.62	Condition		
Planmobility Index: Hygrassopielty: % 30°C, 90% RH	0.62	Condition Chr. ge Diameter, in. Density, gm/cc		

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regmentation Tests	Shaped Charge Utlasticas, THY == 100:	
90 mm HE, M71 Projectile, Let WC-P1:	Glass Cones Steel Cones	
Density, gm/cc	Hole Volume	
Charge Wt, ib	Hole Depth	
Tatel No. of Progmatic: For TNT	Culor	
For Subject HE	Principal Usan	
3 inch HE, M42A1 Projectile, Let KC-5:		
Density, gm/cc		
Charge Wt, Ib		
Total No. of Progmants: For TNT	Mathed of Louding:	
For Subject HE		
	Looding Bunnity; gm/cc	
An 9 tt		
At 25% tt	Storages	
Density, gm/cc	Mathod	
fast (Relative to TVT):	Hazard Class (Quantity-Distance)	
Ain a state of the second s	Competibility Group	
Posk Pressure	P	
impulse Energy	Enudation	I I
	65.5°C KI Test:	
Air, Cuntined: impulse	Minutes 60+	
Under Water:	134.5°C Heat Test:	Į
Pack Pressure	Selmon Pink 20	1
impulse Energy	Red Funes 25 Explodes 300+	
Underwennd:	240-Hour Hydrolysis Test:	
Peak Pressure Impulse	≸ HINO <sub>3</sub>	
Energy	Heat of:	
	Combustion, cal/gm 2960 Explosion, cal/gm 900 Gas Volume, cc/gm 838	-

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#### PVN (Polyvinyl Nitrate)

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#### Preparation:

Polyvinyl alcohol is mixed with acetic anhydride. The mixture is cooled to  $-5^{\circ}C$  and the nitric acid is added slowly while the mass is being stirr  $\sqrt[4]$ . The temperature is clatrolled by the rate of acid addition so that when all the acid has been added the temperature does not rise above 20°C.

When the nitration is complete, the wixture is drowned by alloving a fine stream . the syrupy liquid to flow from the nitrator and mix intimately with a large stream of water. This causes the product to precipitate in a fine state.

The finely divided precipitate is purified by boiling in frequent changes of water.

#### Origin:

The first preparation of polyvinyl nitrate was reported in 1929 by solution of polyvinyl alcohol in concentrated sulfuric acid and treatment with nitrating acid at a temperature not over 50°C. (German Patent 537,303). Later patents issuel relative to polyvinyl nitrate included U. S. Patent 2,118,487 (1938) and German Patent 737,199 (1943).

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RIPE

Composition:	Molocular Wsight:	230
	Oxygen Belence:	•
<b>RDX</b> 85	CO. % CO %	-70
Gulf Crown E Oil 15		- 35
	Density: gm/cc Hand tamped	1-37
	_ Mohing Peint: "C	
C/hi Ratio	Freezing Point: "C	
npost Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 53	Boiling Pelut: *C	
Sample Wt 20 mg	Refrective Index, nº	
Picetinny Arsenal Apparatus, in. 13	12	
Sample Wt, mg 25		•.
Teletien Pendukum Teet:		
Steel Shop Unaffected	Vocuum Steblility Test:	
Fiber Shoe. Unaffected	cc/40 Hrs, at 90°C	
Taken Artigings Class I accord		0.34
Rills Bullist Impost Test: Trials	120*C	0.56
<b>%</b>	135°C	
Explosions 0	150°C	-
Partials 0		
Durned 0	200 Gram Bomb Sand Test:	40.1
Unaffected 100	Sand, gm	
Explosion Texaporature: *C	Sensitivity to Initiation:	
Seconds, 0.1 (no cop used)	Minimum Detonating Charge, gm	
] 5 Decomposes; no value obtained	Mercury Fulminate	
10		0.20
15	Tetryl	
20	Sellistic Merter, % TNT: (a)	118
	Treuzi Test, % TNT:	
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Test: (b)	
70 LOUG IN 40 F175	Method	в
60°C Heat Test:	Condition H	and tamped
% Loss, 1st 4# Hirs 0.03	Confined	No
% Loss, 2nd 48 Hrs	Density, gm/cc	1.37
Euclasian in 100 Hrs None	Brisonce, % TNT	85
Nammability Index:	Confinement	Norat
		and tamped
Tygesseepisity: % 30°C, 90% RH 0.04	Charge Diameter, in.	1.0
Veletility:	Density, gm/cc	2.37

stand Charles Stand	R		ANCP 706-17
Fregessantation Test:		Shippet Charge Effectivenes	L TNT = 100:
90 mm HE, M71 Frejastils, Let WC-	<b>9</b> }:	Glass Cone	s Steal Cones
Density, gm/cc	2.36	Hole Volume	
Charge W 15	1.750	Hole Diepth	
	3.8		1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1
Total Mo. of Fregments:		Čeior:	White
For TNT	703	1. The second	WILL UM
For Subject HE	592		
the second s	say .	Principal Usin: Plastic	demolition explosive
3 thes HE MARAT Projectile, Lat KC	<b>-5:</b>		
Density, genrec	1.42	19 y 1	
Chorge Wt, to	0.756		
	Giordan II		
Total Np. of Fragmontal	•	Skethod of Looding:	Hand tamped
For TNT	514	,	
For Subject HE	501		
	the second	Leading Density: gm/cc	1.37
Fragment Velocity: ft/sec			
At 9 ft	2650 2370		
Ar 25% ft		Storage:	
Density, gm/cc	1.395	Method	Dry
Blast (Relative to TNT):		Hazard Class (Quantity-C	Vistance) Class 9
Ain		Compatibility Group	Group I
Peok Pressure		None at	85°C in 30 hrs
Impulse		Exudation None at	95°C in 48 hrs at 105°C in 48 hrs
Energy		Exudes	at 105°C in 46 hrs
Air, Confined:		Origin:	
Air, Cennies: Impulse			ixture of RDX and Gulf
••••		Crown E 011, was devel	oped in the United Sta
Under Water:		during World War II.	
Peak Pressure		References;""	
Impulse			E. G. Eyster, Physics
Energy		Testing of Explosives,	Pert III - Miscelland
		Sensitivity Tests; Per	formance Tests, OSRD 1
Underground: Peak Pressure		port No. 146, 27 Dece	mber 1947.
		(b) D. P. MacDougal	1, Methods of Physical
Impulse		Testing, USRD Report N	lo. 003, 11 August 1943
Energy		(c) Also see the fo	llowing Picatinny A.m.
Preparation:		Technical Reports on F	IPE: 1713, 1695 and 1
RIPE is manufactured by sin	mple mechanical		
mixing of RDX in oil.		1	

<sup>68</sup>See footnote 1, page 10.

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#### Silver Azide

Composition: %	Melecular Weight: (AgN <sub>3</sub> ) 150
∽ N 28.0 Ag 72.0	Cxygen Belence:         -5           CO2 %         -5           CO %         -5
$A_{G-N=N} = N$	Density: gm/cc Crystal 5.1
C/H Ratio	Mobing Point: "C (a) 251 Decomposes repidly above molting point to Freezing Point: "C silver and nitrogen.
Impact Sensitivity, 2 Kg Wt:	Boiling Point: "C
Bureau of Mines Apparatus, cm 6 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 3 Sample Wt, mg 18	Refrective Index, ng, ng, ng,
Friction Fondulum Text: PA Smill Apparatus Steel Shoe Detonates	Vecuum Stebility Test: cc/40 Hrs, at
Fiber Shoe Detomates Rifle Builtst Impoct Test: Trials % Explosions	90°C 100°C 120°C 135°C 150°C
Partials Burned Unaffected	200 Gram Bamb Sand Test: Sand on (b) Black powder fuse 18.9
Explacion Temperature: *C Seconds, 0.1 (no cap used) 310 1 5 Explodes 290 10	Sensitivity to Initiation: Minimum Detonoring Charge, gm Mercury Fulminate Lead Azide Tetryl
15 20	Ballistic Martar, % TNT:
	Trouzi Test, % Hg(ONC)2 (c) 88
75°C International Heat Test: % Loss in 48 Hrs	Plate Dent Test: Method
100°C Heat Test: % Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs Explosion in 100 Hrs	Condition Confined Density, gm/cc Brisance, % TNT
Flemmebility Index:	Detenstion Rate: Confinement
Mygrescepicity: % (b) 25°C, 100% RH 0.04	Condition Charge Diameter, in.
Veletility: 75°C, 24 hrs 0.00	Density, gm/cc     Rate, meters/second

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Silver Azide

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Freqmentation Test:	Shaped Charge Effectiver see, TNT = 10	<b>10</b> :
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Giass Cones Steel C Hole Valume Hole Depth	ones
Total No. of Progmants: For TNT	Color: White	to gray
For Subject HE 3 inch HE, M42A1 Projectile, Lot KC-S: Density, gm/cc Charge Wt, Ib	Principal Uses: Ini	tistors
Total No. of Fragments: For TNT	Mathod of Looding: Pres	\$6. <sup>1</sup>
For Subject HE	Leading Density: gm/cc Veri	able
At 9 ft At 25½ ft Damity, gm/cc	Storage:	
Blast (Relative to TNY):	Method Hazard Closs (Quantity-Distance)	Wet Class 9
Ain: Pack Pressure	Compatibility Group	(Loup N
Impulse Energy	Exudation	None
Air, Costinut: Impute	Initiating Efficiency: Grams Required to Give Complete Initiation of TWT	(c) 0.02-0.05
Under Weter: Peak Pressure Impulse	Solubility in 100 gm Solvent at Room Temperature:	
Energy	Solvent Water (b)	<u>Grame</u> 0.006
Underground: Pook Pressure Impulse	Ammonium hydroxide Nitric scid Ether (b)	Soluble Decomposes 0.017
Energy Explosive Power: (f)	Etk 1 alcohol, 95% Acetone Unaffected by water and CO <sub>2</sub> .	0.006 0.015 (d)
Kilogram meters 192,000 \$ Mercury Fulminate 1.097	Heat of: Explosion, cal/gm (c, a) Formation, cal/gm (c)	452 67.8

#### AMCP 706-177

#### Silver Azide

#### Preparation;

 $\operatorname{MaN}_3$  + AgNO<sub>3</sub>  $\rightarrow$  AgN<sub>3</sub>  $\downarrow$  + NaNO<sub>3</sub>

Prepare the following aqueous solutions:

- . a. 5% NaN3, sodium azide, 50 cc
  - b. 25% AgNO3, silver nitrate, 25 cc

The silver nitrate solution is placed in a 200 cc conductive rubber beaker equipped with a hard wood stirrer operated by an air motor. The sodium azide solution is placed in a separatory funnel fastened in a ring stand above the beaker containing the silver nitrate. A long cord (10 ft) is restaned to the stopcock of the separatory funnel so that the funnel can be explied by remote control. The silver nitrate solution is now stirred very repidly and the sodium axide is slowly run into the nitrate solution. Stirring is continued for 5 minutes. The contents of the beaker are filtered through folded filter paper and vashed free of sodium axide and silver nitrate with distilled water.

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Silver aside should be stored under water in a conductive rubber container. This preparation yill yield approximately 7 grams.

The preparation should be conducted under a hood and behind a barricade. The product obtained by the above procedure has a very fine particle size, almost colloidal. Very fine silver axide is safer to handle and is just as efficient and stable as the large, coarse crystalline material (Ref b). When a thin film of fine silver axide is precipitated on mercury fulminate. tetryl, etc., these substances are as efficient weight for weight as pure silver axide (Ref g). White silver axide is less affected by light than mercury or lead axide (Ref h). Long colorless crystals which explode on breaking are obtained from amnonium hydroxide.

#### Origin:

Statistical Statistics

Silver azide was first prepared in 1890-1 by T. Curtius (Ber 23, 3032; Ber 24, 3344-5) by passing hydrazoic acid  $(HM_3)$  into neutral silver nitrate solution. Taylor and Rinkenbach prepared pure "collodial" aggregates and showed its sensitivity depends upon its particle size (Army Ordnance 5, 824 (1925). Silver azide was found in a detonator of foreign ammunition for the first time in 1945 (Ref 1).

#### References:69

(a) A. R. Hitch, "Thermal Decomposition of Certain Inorganic Trinitrides," J Am Chem Soc 40, 1195 (1918).

(b) C. A. Taylor and Wm. H. Rinkenbach, "Silver Azide: An Initiator of Detonation," <u>Army</u> Ordnance, Vol 5, p. 824 (1925).

- (c) E. De W. S. Colver, High Explosives, London and New York, p. 527.
- (d) A. Stettbacher, Spreng u. Schlesstoffe, Rascher, Zurich, p. 97 (1948).
- (e) A. Marshall, Explosives, 2nd Ed, Vol II, p. 767, London.
- (f) A. Stettbacher, Z ges Schiess-Sprengstoffy 10, pp. 193-214 (1915).

69See footnote 1, page 10.

#### Silver Aside

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323

(g) F. Blechta, Chim et Ind Special No. 921-5 (June 1933); C. A. 28, 646.

(b) L. Wohler and W. Krupko, Barichte 46, 2047-2050 (1913).

(1) F. G. Haverlak, Emmination of 120/45 NM HE Shell, Italian (FMAN-464), PATR No. 1515, 10 April 1945.

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106.85

#### Tetracene

Composition:		Melecular Weight: (C2H8N100)	188
C 12.8	ł	Oxygen Belence: CO <sub>2</sub> % CO %	-60 -43
H 4.3 C-NH-NH-N = N-C N 74.4		Density: gm/cc At 3000 psi	1.05
0 8.5 <sup>MH</sup> 2 M	H–NH–NO	Maiting Point: "C Explodes	140-160
C/H Ratio 0.068		Freezing Point: *C	
Impact Sanskivity, 2 Kg Wt:		Boiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in.2; (8 Sample Wt, mg	7 oz vt) 8	Refrective Index, ng ng ng	
Friction Pondulum Test:	<u></u>	Vocuum Stability Test:	
Steel Shoe		cc/40 Hrs, at	
Fiber Shoe		90°C	
Rifle Bullet Impact Test: Trials		120°C	
Sectorization %		135°C	
Explosions Portials		150*C	
Burned		200 Grem Bemb Sand Test:	
Unoffected			28.0
		Sond om Black boyder fuse 4.0	
Explosion Temperature: *C Seconds, 0.1 (no cap used)		Sensitivity to Initiation: Minimum Detonating Charge, gm	
]		Mercury Fulminate	0.40
5 160		Lead Azide	
10		Tetryi	
15			
20		Bolliotic Mortor, % TNT:	
		Treuzi Test, % TNT: (a)	61
75°C International Heat Test: % Loss in 48 Hrs	0.5	Plate Dont Test: Method	
100°C Heat Test:		Condition	
% Loss, 1st 48 Hrs	23.2	Confined	
% Loss, 2nd 48 Hrs	3.4	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TNT	
Pl		Detenation Rate:	
Flommability Index:		Confinement	
Hygrescepicity: % 30°C, 90% RH	0.77	Condition Charge Diameter, in.	
		Density, gm/cc	
Veletility:		Rate, meters/second	

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#### Tetracene

AMCP 706-177

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Fregmentation Test: Shaped Charge Effectiveness, TNT =	
99 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Giass Cones Steel Cones Hole Valume Haie Depth
Total No. of Fragments: For TNT	Color: Pale yellow
For Subject HE 3 insh HE, M42A1 Projectile, Let KC-3: Density, gm/cc Charge Wt, Ib Tablable of Terrenation	Principal Una: Priming compositions and detonators
Total No. of Fragments: For TNT For Subject HE	Method of Looding: Pressed
Frogment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc	Leeding Density: gm/cc At 3000 psi 1.05 Storage: Method Wet
liest (Relative to TNT):	Hazard Class (Quantity-Distance) Class 9
Air: Peok P.essure Impulse Energy	Compatibility Group Group M Exudation
Air, Confined: Impulse Under Weter: Peak Pressure Impulse Energy	Solubility: Practically insoluble in water, alcohol, acetone, ether, benzene, carbontetrachloride or ethylenedichloride. Sensitivity to Electrostatic <u>Discharge, Joules:</u> (b)
Underground: Peak Pressure Impulse Energy	Unconfined 0.010 Confined 0.012 Heat of: Explosion, csl/gm 658 Gas Volume, cc/gm 1190
	Initiating Efficiency: Tetracene is not efficient in initiating high explosives.

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#### Tetracene

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#### Preparation:

(Rinkenbach and Burton, Army Ordnance 12, 120 (1931)).

Tetracene is prepared by dissolving 5 gms of eminoguanidine dinitrate in 30 cc of water, cooling to  $0^{\circ}$ C and mixing with a solution of 2.5 gms of sodium nitrate in 15 cc of water. The temperature is maintained at about  $10^{\circ}$ C and 0.5 gm of acetic acid is added. The tetracene separates out and is washed with water, alcohol and ether. It is then dried.

Tetracene may also be prepared by placing aminoguanidine sulphate and sodium nitrite in a large beaker and adding water her led to  $30^{\circ}$ C. The heat of reaction causes the mixture to boil; after standing for two or three hours the separated tetracene is filtered off, washed thoroughly and dried.

#### Origin:

Tetracene was first prepared in 1910 by Hoffman and Roth (Ber 43, 682) who also studied its chemical reactions and determined its structure (Hoffman et al, Eer 43, 1087, 1866 (1910); Ber 44, 2496 (1911); and Ann <u>380</u>, 131 (1911)). W. H. Rinkenbach and O. Burton made an extensive study of tetracene and described its manufacture and explosive properties (Army Ordnance <u>12</u>, 120 (1931)).

#### Destruction by Chemical Decomposition:

Tetracene is decomposed by adding it to boiling water and continuing boiling for some time to insure complete decomposition.

#### References: 70

(a) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

L. C. Smith and E. G. Eyster, Physical Testing of Explosives. Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) F. W. Brown, D. H. Kusler and F. C. Gibson, <u>Sensitivity of Explosives to Initiation</u> by <u>Electrostatic Discharges</u>, U. S. Dept of Int, Bureau of Mines, RI 3852, 1946.

(c) Also see the following Picatinny Arsenal Technical Reports on Petracene:

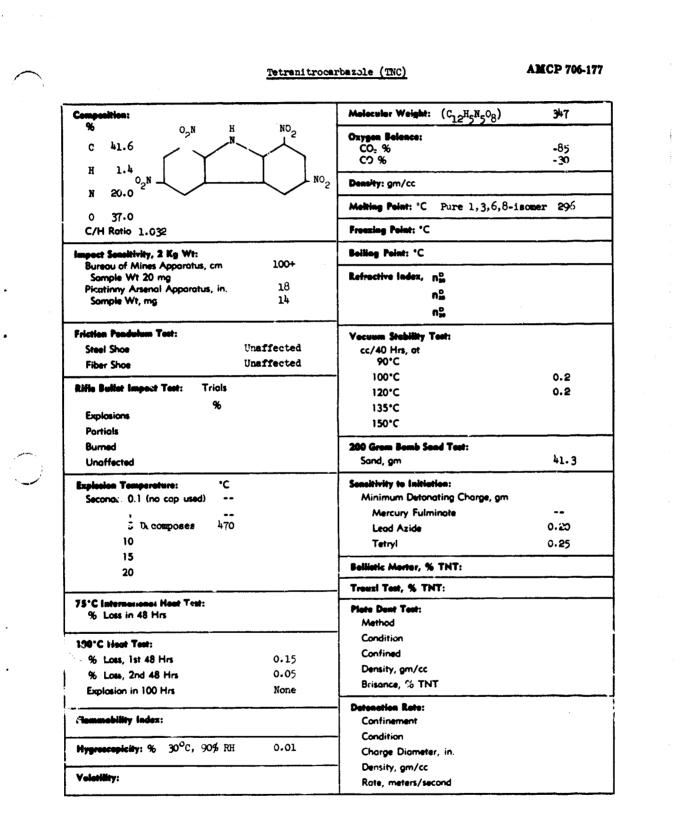
<u>o</u>	<u>1</u>	<u>3</u>	<u>4</u>	<u>7</u>	8	2	
1450	11	453	1104 2164	407	318	859 2179	

70see footnote 1, page 10.

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#### AMCP 706-177

#### Tetranitrocarbaso?.e (TNC)

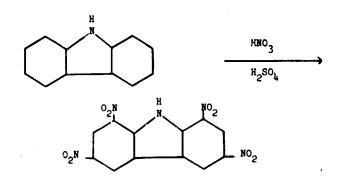
Fragmentation Test:	Shaped Charge Effectivenese, THT = 1	<b>00:</b>		
99 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib	Gicss Cones Steel ( Hole Volume Hole Depth	Cones		
Total No. of Fragments: For TNT	Color: Li	ght yellow		
For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib		I ight yellow I ight yellow Maponent of igniter and Totechnic compositions Preased /cc a Dry ontity-Distonce) Class 9 up (intro- class 9 up 0.10 Solubility Very soluble Solubile Insoluble Insoluble Insoluble Insoluble Insoluble Insoluble Insoluble		
Total No. of Fregments: For TNT For Subject HE	Method of Looding:	Pressed		
Fregment Velocity: ft/sec	Leading Denvity: gm/cc			
At 9 ft At 25½ ft Density, gm/cc	Storege: Method	Dry		
Blast (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 9		
Air: Peak Pressure Imputse Energy	Compatibility Group Exudation			
Aiz, Confined: Impulse	Solubility in Water, gm/100 gm (\$), at:			
Under Weter: Peak Pressure	95°C <u>Qualitative Solubilities:</u>	0.10		
Impulse Energy	<u>Solvent</u> Nitrobenzene	Very soluble		
Underground: Peak Pressure Impulse Energy	Acetone Benzene Chloroform Carbontetrachloride Ether Ether, petroleum	Insoluble Insoluble Insoluble Insoluble		

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#### Tetraniirocarbazole (TNC)

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Preparation:



Sulfonation: Fifty-six gms of carbazole is dissolved in 320 gms of  $H_2SO_1$  (96%, specific gravity 1.84). The solution is agitated during the addition of the carbazole and the temperature maintained at  $25^{\circ}-35^{\circ}C$ . After the addition of the carbazole is completed, the agitation is continued and solution completed by raising the temperature to  $80^{\circ}-85^{\circ}C$  and maintaining this temperature for one hour. The sulphate is now cooled to  $20^{\circ}C$ .

<u>Mitration</u>: The sulfonate solution is slowly added to 168 gms of HNO<sub>3</sub> (Plant grade specific gravity 1.525 at 15°C) saintaining the temperature at 30° to 50°C. (Time required - 1 hour 25 minutes). The temperature is then gradually raised to 70° to  $75^{\circ}$ C and maintained for one hour after which the temperature is reised to 85° to 90°C and held for one hour, then lowered to room temperature before drowning.

Drowning: The nitration mixture is drowned by pouring it into 2 to 3 volumes of ice and water.

Filtering: The separated light yellow product is filtered on a Buchner Funnel and washed with water twice to remove most of the acid.

<u>Purification:</u> The TNC is placed in hot water  $(95^{\circ} \text{ to } 100^{\circ}\text{C})$  and boiled for five to ten minutes with rapid agitation, allowed to settle then filtered and washed once. This procedure is repeated twice, making a total of three "boilings." The final wash is acid free.

Drying: The TNC is spread in a thin layer and dried at 100° to 110°C for four hours.

<u>Yield:</u> 73.3%.

Melting Point of TNC as prepared: 280°C (compares to 296°C for pure 1,3,6,8-isomer in preceding data).

#### Origin:

The preparation of Tetranitrocarbazole (TNC) was first reported in 1880 by C. Graebe (Ann 202, 26 (1880)) who nitrated carbazole with 94% nitric acid. Similar procedures were followed by R. Escales (Ber <u>37</u>, 3596 (1904)) and P. Zierch (Ber <u>42</u>, 3800 1909)). However, G. L. Ciamician and P. P. Silber observed the formation of four isomeric TNC's when acetyl carbazole was treated with fuming nitric acid (Gazz chim ital <u>12</u>, 272 1882). In 1912 and 1913 patents were issued to the dyestuff manufacturer, Casella and Company, covering the preparation of polynitrocarbazoles (German Patent 268,173 and French Patent 464,53%). The Casella process of

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/IVALEBOOK

#### Tetranitrocarbazole (TNC)

preparing polynitrocarbazoles by dissolving carbazole in sulfuric acid and treating the solution of sulfonic acids with strong nitrating agents is essentially the process used today in the United States. The crude product, thus prepared, contains principally 1,3,6,8-TMC (W. Borsche and B. G. B. Scholten Ber 50, 596 (1917) and about 10% of the 1,2,6,8-TMC isomer (D. B. Murphy et al J Am Chem Soc  $\frac{75}{15}$ , 4289 (1953). TMC was used in explosives by the Germans during World War II.

#### References: 71

(a) D. B. Murphy, F. R. Schwartz, J. P. Picard and J. V. R. Kaufman, "Identification of Isomers Formed in the Nitration of Carbazole," J Am Chem Soc, <u>75</u>, 4289-4291 (1953).

(b) S. Livingston, <u>Preparation of Tetranitrocarbazole</u>, PA Chemical Research Laboratory Report No. 136,330, 11 April 1951.

(c) D. B. Murphy et al, Long Range Basic Technical Research Leading to the Development of Improved Ignition Type Powders - The Chemistry of Tetranitrocarbazole, PA Memorandum Report No. 22, 2 September 1952.

- (d) S. Livingston, <u>Development of Improved Ignition Type Powders</u>, PATR No. 2267, July 1956.
- (e) Also see the following Ficatinny Arsenal Technical Reports on Tetranitrocarbazole:

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#### 2,4,2',4'-Tetranitro-oxenilide (TNO)

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Composition:	0	Melecular Weight: $(C_{14}H_8N_6O_{10})$	420
% ( c 40.0 c	¥	Oxygen Belence:	<u>.</u>
Ī	<u> </u>	CO2 %	-84
H 1.9 NH	NH	CO %	- 3).
N 20.0	NO2 NO2	Density: gm/cc	
0 38.1		Melting Point: °C Decomposes	313
C/H Ratio 0.735 NO2	NC2	Freezing Point: "C	
Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm		Boiling Point: °C	
Sample Wt 20 mg		Refrective Index, na	× .
Picatinny Arsenal Apparatus, in. Sample Wt, mg	30 11	na	
Jumple Willing	**	n <sub>30</sub>	
Friction Pondulum Test:		Vocuum Stability Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	
	······	- 100°C	
Rifle Bullet Impoct Test: Trials		120°C	0.11
% Explosions		135*C	
Partials		150°C	
Burned		200 Grow Beenh Ser d Texts	
Unoffected		200 Grem Bomb Send Text: Sand, gm	16.3
Explosion Temperature: °C		Sensitivity to Initiation:	
Seconds, 0.1 (no cop used)		Minimum Detonating Charge, gm	
1 5 302	·. ·	Mercury Fulminate	
5 <u>392</u> 10		Lead Azide	0.20
15		Tetryl	0.25
20		Bellistic Morter, % TNT:	
		Treuzi Test, % TNT:	
75°C international Heat Test: % Loss in 48 Hrs		Plate Dest Test:	
		Method	
100°C Heat Test:		Condition	
% Loss, 1st 48 Hrs	0.07	Confined	
% Loss, 2nd 48 Hrs	0.00	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TNT	
- -		- Detonation Rate:	
Flammebility Index:		Confinement	
Hygrescepicity: % 30°C, 90% RH	Trace	- Condition Charge Diometer, in.	
Veletility:	<u></u>	Density, gm/cc	
		Rate, meters/second	

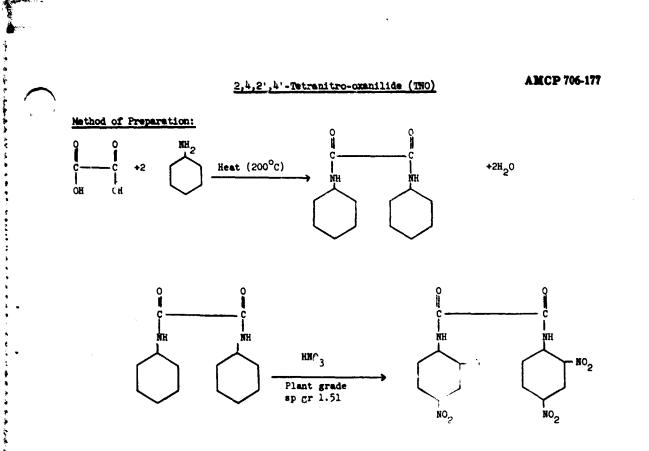
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#### 2,4,2',4'-Tetranitro-oxanilide (TNO)

Fregmentation Test:	Sheped Charge Effectiveness, TNT = 100:			
99 mm HE, M71 Projectile, Let WC-91; Eursity, gm/cc Charge Wt, ib	Glass Cones Steci Cones Hole Volume Hole Depth			
Total No. of Fragmanis: For TNT For Subject ME	Color: Light yellow			
For Subject ME <b>3 inch HE, M42A1 Projectile, Let KC-5:</b> Density, gm/cc Charge Wt, Ib	Principal Uses: Component of black powder type and pyrotechnic compositions			
Total No. e <sup>e</sup> Fragmants: For TN F For Sub act HE	Method of Loading: Pressed and extruded compositions			
	Looding Density: gm/cc			
Fregment Velocity: ft/sec At 9 ft At 25½ ft	Storage:			
Density, gm/cc	Method Dry			
Elast (Relative to TNT):	Hazard Class (Quantity-Distance) CLass 9			
Air: Peak Prassure Imputse Energy	Compatibility Group Exudation			
Air, Confined: Impulse	Solubility, gm/100 cc Solvent, in: <u>°c</u> źź			
Under Water: Peok Pressure	Water100<0.10			
Impulse Energy	Qualitative Solubilities:           Solvent         Solubility			
Underground: Peok Pressure Impulse Energy	Ethyl alcoholInsolubleBenzeneInsolubleButyl acetateInsolubleCarbontetrachlorideInsolubleEthyl etherInsolubleAcetic acidSolubleNitric acidSolubleCaustic potashSolubleDimethyl fornamideVery soluble			

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#### Omanilide:

 Two parts of oxalic soid are mixed with one part of aniline in a round bottom flask. The mixture is stirred and heated until the reaction is complete as evidenced by the cessation of effortescence. The mass is cooled to room temperature, poured into several volumes of water  $(21^{\circ}-24^{\circ}C)$ , filtered on a Büchner funnel and washed free of oxalic acid with water and then washed free of aniline with acetone. The oxanilide is air dried to remove the acetone and then dried at  $100^{\circ}-110^{\circ}C$ .

#### Tetranitro-oxanilide (TNO):

A 5 liter round bottom flask is equipped with a stirrer of a type which will produce a acwnward "swirl." The flask is surrounded with a water jacket for hot and cold water. Fifteen hundred grams (1.5 kilograms) of 96% plant grade nitric acid is placed into the flask. Five hundred (500) grams of omanilide is slowly added to the acid under rapid agittion while the temperature is maintained below  $40^{\circ}$ C. After the addition of the oxanilide is completed ( $2\frac{1}{2}$ -3 hrs), the agitation is continued 10-15 minutes. The temperature is then raised to  $80^{\circ}$ C over a period of ons hour and maintained at  $80^{\circ}$ -85°C for 3 hours. The scid slurry is then cooled to room temperature and drowned by pouring over cracked ide. The product is filtered on a Büchner funnel and washed with water until it is almost acid free. The filter cake is placed in a beaker and sufficient water added to form a "slurry." Live steam is run into the "slurry" under agitation for 10 minutes. The slurry is filtered and the residue washed. The latter treatment of the "slurry" is repeated until the wash water is found to be neutral to

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#### 2,4,2',4' Tetranitro-oxanilide (TNO)

litmus paper. The TNO is washed with alcohol, then acetone, air dried and finally dried at 100°-110°C.

Yield = 90% to 97.5% of theoretical.

#### Origin:

A. G. Perkin in 1892 obtained tetranitro-oxanilide directly by heating a solution of finely powdered oxanilide in nitric acid. He also obtained the same compound by the action of a cooled mixture of nitric and sulfuric acids on oxanilide and precipitating the product by pouring the solution into water (J Chem Soc  $\underline{61}$ ,  $\underline{460}$  (1892).

#### References: 72

(a) S. Livingston, <u>Development of Improved Ignition Type Powders</u>, PATR No. 2267, July 1956.

(b) D. Dubrow and J. Kristal, Substitution of Tetranitro Oxanilide and Hexanitro Oxanilide for Tetranitro Carbazole, PA Pyrotechnic Pesearch Laboratory Report 54-TF 1-88, 20 December 1954.

<sup>72</sup>See footnote 1, page 10,

Tetryl

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Composition:		Molecular Weight: (C7H5N508)	287
% H <sub>3</sub> C−N	_	Oxygen Belence: CO <sub>2</sub> %	-47 - 8
H 1.7 0 <sub>2</sub> N	- NO <sup>5</sup>	CO %	• 0
N 24.4		Density: gm/cc Crystal	1.73
0 44.6		Malting Point: "C	130
C/H Ratio 0.420 N	0 <sub>2</sub>	Freezing Point: "C	•
Impuct Sensitivity, 2 Kg Wt:	~	Beiling Point: "C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg	26 8 18	Refrective Index, nº nº nº	<u> </u>
Friction Pendulum Test:			<u></u>
Steel Shoe	Crackles	Vecuum Stebility Test: cc/40 Hrt. at	
Fiber Shoe	Unaffected	90°C	
	<u></u>	- 100°C	0.3
Rifie Bullet Impact Test: Tric!s		120°C	1.0
% Explosions 13		135°C	
Partials 54		150°C	11+
Burned 10		200 Grem Bomb Send Test:	
Unoffected 23		Sand, gm	54.2
Explasion Temperature: °C		Sensitivity to Initiation:	
Seconds, 0.1 (no cap used) 340		Minimum Detonating Charge, gm	
1 <u>314</u>		Mercury Fulminate	0.20*
5 Ignites 257		Leod Azide	0.10*
10 238 15 236		*Alternative initiating Charge	6.
20 234		Beilistic Morter, % TNT: (a)	130
	······································	Treval Test, % TNT: (b)	125
75°C International Host Test: % Loss in 48 Hrs	0.03	Plate Deat Test: (c)	······································
70 LOSS IN 40 MIS	0.01	Method A	в
100 'G Heat Test:	······	Condition Pressed	Pressed
% Loss, 1st 48 Hrs	0.1	Confined Yes	No
% Lass, 2nd 48 Hrs	0.0	Density, gm/cc 1.50	1.59 1.36
Explosion in 100 Hrs	None	Brisance, % TNT 116	115 96
Flammability Index:	244	- Detenction Rote:	None
		- Confinement	Presse
Hygroscopicity: % 20°C, 90% RH	0.04	Charge Diometer, in.	1.0
		Density, gm/cc	1.71
Veletility: 25°C	0.00		7850

335

#### AMCP 706-177

Construction of

letryl

Reaster Sensitivity Test:	(d)	Decomposition Equation: (6) (h) Oxygen, atoms/sec 10 <sup>15.4</sup> 10 <sup>12.9</sup>	
Condition	Pressed		
Tetryi, gm	100	(Z/sec) Heat, kilocalorie/mole 38.4 34.9	
Wax, in. for 50% Detonation	2.01	(AH, kcal/mol)	
Wax, gm		Temperature Range, °C 211-260 132-164	
Density, gm/cc	1.58	Phose Liquid Liquid	
Heat of:		Armer Plate Impect Test:	
Combustion, col/gm	2925		
Explosion, cal/gm	1080-1130	60 mm Mortar Projectile:	
Gas Volume, cz/gm	760	50% Inert, Velocity, ft/sec	
Formation, cal/gm	-14	Aluminum Fineness	
Fusion, cal/gm (e) Temperature, C	22.2 127	500-16 General Purpose Bambo:	
Specific Hest: cal/gm/*C	(e)		
-100	0.182	Plate Thickness, inches	
- 50	0.200	· · · · · · · · · · · · · · · · · · ·	
0	0.212		
50	0.223	11/4	
100	0.236	11/2	
		134	
Burning Rate: cm/sec			
		Bamb Drap Tast:	
<b>Thermal Conductivity:</b> (1) col/sec/cm/*C 5.81 x 10 <sup>-1</sup> / <sub>-</sub> at 6.83 x 10 <sup>-4</sup> at	1.394 gm/cc	T7, 2000-Ib Sami-Armor-Plancing Bamb vs Concreto:	1
	1. 20 84/ 00	Max Safe Drop, ft	
Coefficient of Expansion: Linear, %/*C			
		500-lb General Purpers fromb v# Concrete:	
Volume, %/°C		Height, ft	
Herdness, Mehs' Scele:		Trials	
		Unaffected	
Young's Modulus:	·····	Low Order	
E', dynes/cm²		High Order	
E, Ib/inch <sup>2</sup>		1900-lb General Purpose Bamb vs Cancrate;	
Density, gm/cc			
Compressive Strength: Ib/inch <sup>2</sup>		Trials	
		Unoffecteo	
Vapor Pressure:		Low Order	
°C mm Mercury		High Order	

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Tetryl

AMCP 706-177

SCA. AND

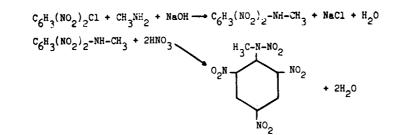
Volume	Glass C	_			
Volume		iones	Steel Co	mes	
Depth					
			Light	yello	
el Vees:			ingredie		
		mixtu: ting ce	res, det	constor	s, an
	0199	orug Ce	270		
of Load				Pres	sed
				L.G.	<i>176</i> 6
) Density:	: gm/cc		See tel	OW	
:					
od				Dr-'	
rd Closs	(Quanti	ity-Dista	nce)	Cla	<b>88</b> 9
patibility	Group			Grou	ıp L
otion		Doe	es not e	xude at	c 65°
Densit	ty: gr	1/cc			
st 1.62	Pre	essed	рві х	10 <sup>3</sup>	
3	5	10	12 1.60	15	
1.40	1.47	1.57	1.60	1.63	1.6
		30			
		1.71			
of Temp	peratur	re on		(3)	
Detons	at.on:				
rs at.	°c		-54		21
sity, gn	n/cc		1.52		53
			7150		70
	hrs at, sity, gr	f Detonsilon: hrs at, <sup>o</sup> C sity, gm/cc e, m/sec	hrs at, °C sity, gm/cc	hrs at, °C -54 sity, gm/cc 1.52	hrs at, <sup>o</sup> C -54 2 sity, gm/cc 1.52 1.

AMCP 706-177

#### Tetryl

#### Preparation:

(Manufacture of Tetryl by Dinitromonomethylaniline Process, Wannamaker Chemical Cc., Inc.)



To a solution of 202.5 gm dinitrochlorbenzene in 200 cc benzene, at  $75^{\circ}$ C with good sgitation, in 15 to 20 minutes, add 112 gm of 30% aqueous monomethylamine. Then add 129 gm of 31% aqueous sodium hydroxide, in 15 to 20 minutes, at such a rate as to cause refluxing; continue agitation for 3 hours at  $70^{\circ}$ C. The mixture is concentrated to a liquid temperature of 101°-102°C, cooled, filtered and the precipitate washed with distilled water until the washings give no test with silver nitrate, dried at  $60^{\circ}$ C (melting point 167.2°C)

The dinitromethylaniline is nitrated to tetryl by solution of it in 88% sulfuric acid (197 gm nitroaniline/1190 gm sulfuric) at  $25^{\circ}$ C, followed by addition of nitric acid. The process is carried out so that the water content remains at 16%. Solution (per 197 gm nitroaniline) requires 5 to 10 minutes, nitration, by addition of the sulfuric acid solution to nitric acid, about 1 hour at  $30^{\circ}$ C, plus 48 minutes at  $50^{\circ}$  to  $55^{\circ}$ C at the end. The mixture is then cooled to  $20^{\circ}$ C and filtered. The tetryl is dumped into 1 liter water, washed 2 or 3 times with 200 cc cold water, and then stirred 10 to 15 minutes at  $50^{\circ}$ C with 500 cc water, filtered warm and then washed with water until the washings are neutral to methal to range. The tetryl dried to constant weight at  $70^{\circ}$ C weighs about 270 gm.

Tetryl filtered from an acid containing 87% sulfuric acid (or more) -13% water, at 40°C (or over) may fire in 30 minutes to 1 hour and 30 minutes, if not drowned in water. A safe nitration procedure, even on plant scale involves:

1. The concentration of sulfuric in the spent acid is maintained at a low level (approx 80/1.6/18.2 sulfuric/nitric/water).

2. Nitration maximum temperature is 50°C.

3. The slurry is cooled to  $35^{\circ}C$  before filtration.

4. Filtration time prior to drowning, is minimized (15 minutes maximum).

The crude tetryl produced is recrystallized to remove impurit  $\pm$  and occluded acid and to control its granulation.

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## **RVIVALEBOOKS.COM**

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			:	<u>letryl</u>				A	ECP 706-177
		electrosta	tic discharge	, joule	s; throu	gh 100 m	esh: (i)		
	onfined fined		0.007 4.4						
			00 grams (%)						
Hat			on tetrachlos			Eth			Alcohol
°c	ž	°c		ž		°c	ž	<u>00</u>	٤
0 20 30 100	0.0050 0.0075 0.0110 0.0810 0.184	0 20 60		).007 ).015 ).058 ).154		0 10 20 30	0.188 0.330 0.418 0.493	0 10 20 30 50 75	0.320 0.425 0.563 0.76 1.72 5.33
Chlo	proforta	Carbon d	isulfide	Ethyl	lene dic	hloride		Acetone	
°c	¥	°c	ž	°c		£	<u>°</u> 0		差
0 20 20 20 20	0.28 0.39 1.20 2.65	0 10 20 30	0.009 0.015 0.021 0.030	25 75		4.5 45	20 30 40 50		75 95 116 138
Trichlor	oethylene	Ethyl ac	<u>tate</u>		Benzene			foluene	
<u>°c</u>	ž	°C	ž	°C		é	<u>°</u>		é
0 66 86 86	0.07 0.12 0.26 0.67 1.50 1.76	20	~ 40	20 30 49 50		7.8 10.0 12.5 16.0	20	•	8.5
		Xy	lene		T	T			
		°c	£		°c	4			
		20 30 40 50	3.3 4.4 5.4 6.0		∂0 100 120	d2 149 645			

#### Origin:

Contraction of the local distance of the loc

Section Accession

• white N 1

Tetryl was first described in 1879 by Michler and Meyer (Ber <u>12</u>, 1792), van Romburgh and Martens studied its properties and proved its structure (Rec trav chin. <u>2</u>, 108 (1883); <u>6</u>, 215 (1887); and Ber <u>19</u>, 2126 (1886)). Tetryl was not used as an explosive until World War I.

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#### AMCP 706-177

#### Tetryl

#### Destruction by Chemical Decomposition:

Tetryl is decomposed by dissolving in 12 times its weight of a solution prepared from 1 part by weight of sodium sulfite (Na<sub>2</sub>SO<sub>2</sub>· $7H_2O$ ) in 4 parts water. The sulfite solution may be heated to  $80^{\circ}C$  to facilitate decomposition of the Tetryl.

#### References: 73

(a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III - Miscellaneous Sensitivity Tests; Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) Ph Naoum, Z ges Schiess --- Sprengstoffw, pp. 181, 229, 267 (27 June 1932)

(c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> <u>Tetryl in Boosters</u>, NOL Memo 10,303; 15 June 1949.

(e) C. A. Taylor and Wm. H. Rinkenbach, "The Solubility of Trinitro-Phenylmethyl-Nitramine (Tetryl) in Organic Solvents," J Am Chem Sic <u>45</u>, (1923) p. 104.

(f) E. Hutchinson, The Thermal Sensitiveness of Explosives. The Thermal Conductivity of Txplosive Materials, AC 2861, First Report, August 1942.

(g) R. J. Finkelstein and G. Gamow, Theory of the Detonation Process, NAVORD Report No. 90-46, 20 April 1947.

(h) M. A. Cook and M. T. Abegg, "Isothermal Decomposition of Explosives," University of Utah, <u>Ind Eng Chem</u> 1090-1095 (June 1956).

(i) J. W. Brown, D. H. Kusler and F. C. Gibson, <u>Sensitivity of Explosives to Initiation</u> by <u>Electrostatic Discharges</u>, U. S. Dept of Int, Bureau of Mines, RI 3552, 1946.

#### (j) W. F. McGarry and T. W. Stevens, Detonation Rates of the More Important Military Explosives at Several Different Temperatures, PATR No. 2383, November 1956.

(k) Also see the following Picatinny Arsen 1 Technical Reports on Tetryl:

<u>o</u>	l	• <u>2</u>	3	4	5	<u>6</u>	<u>7</u>		2
30 600 770 810 1290 1350 1350 1400 1450 1510 1510	11 361 381 621 1041 1131 1261 1331 1431 1471 1611 1651	132 582 832 1352 1352 1372 1402 1452 1592	453 493 623 833 963 1113 1373 2053 2163 2233	84 144 294 314 694 7784 874 904 1134 116 1234 1264 2024 2204	65 195 525 565 6235 925 1145 1285 1265 1935 2105	266 556 986 1086 1126 1316 1316 1416 1446 1556 1636 1956	117 197 637 707 807 807 857 1047 1137 1287 1337 1337 1437 1797 1937	28 438 628 708 838 1418 1769 1828 1838	129 179 319 609 709 849 939 1029 1209 1379 1429 1489 1819 1969
		. N. 1			2125 2205				

<sup>&</sup>lt;sup>3</sup>See footnote 1, page 10.

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Tetryto', 80/20

#### AMCP 706-177

Composition: %		Molecular Weight:	274
<del>w</del> Tetryl	80	Oxygen Belence:	
		CO <sub>3</sub> %	-52
TNT	20	CO %	-11
		Density: gm/cc Cast	1.51
		Molting Point: "C	68
C/H Ratio		Freezing Point: "C	
impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	28	Boiling Feint: 'C	
Sample Wt 20 mg	0	Refrective Iwdex, no	
Picatinny Arsenal Apparatus, in. Sample Wt, mg	9 17	ng	
	• I	n <u>2</u>	
Friction Pondulum Test:		Vecuum Stability Test:	
Steel Shoe		cc/40 Hrs, at	
Fiber Shoe		90°C	
Rifle Bullet Impact Test: Trials			3.0
%		120°C	11+
Explosions 0		135°C	
Partials 20		150°C	
Burned 0		200 Grem Bomb Send Test:	
Unoffected 80		Sand, gm	54.0
Explosion Temporetare: *C		Sensitivity to Init(_tion:	
Seconds, 0.1 (nc cop used)		Minimum Detonating Charge, gm	
1 5 Tanina - Con		Mercury Fulminate	0.22*
5 Ignites 290		Leod Azide	0.17*
15		*Alternative initiating charges.	
20		Bellistic Morter, % TNT:	
		Trouzi Test, % TNT:	
75°C International Heat Test: % Loss in 48 Hrs		Plate Dent Test:	
		- Method	
100°C Heat Test:		Condition	
% Loss, 1st 48 Hrs	0.1	Confined	
% Loss, 2nd 48 Hrs	0.5	Density, gm/cc	
Explosion in 100 Hrs	None	Brisance, % TNT	
Flammability Index: Will not cont	inue to burn	- Outonation Rate: Confinement	
Hygreecepicity: %	0.02	Condition Charge Diameter, in.	
Velatility:	······	Density, gm/cc	
		Rate, meters/second	

#### AMCP 706-177

#### Tetryto1, 80/20

		·
Fragmentation Test:	Shaped Charge Effectivener, TNT = 10	0:
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Chr: ge Wt, Ib	Glass Cones Steel C Hole Volume Hole Depth	ones
Total No. of Frogments; For TNT	Coler: Light ye	llow to buff
For Subject HE	Frincipel Uses: Bursters, demolit	ion blocks
3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib		
Total No. of Fragments: For TNT For Subject HE	Method of Looding:	···
	Looding Density: gm/cc	
Fregment Yelecity: tt/sec At 9 ft At 25½ ft	Storage:	
Density, gm/cc	Method	Dry
Blast (Relative to TNT):	Hazard Class (Quantity-Distance)	Class 9
Air: Peak Pressure Impulse Energy	Compatibility Group Exudation Pacade	Group I
Air, Confined: Impulse		
Under Water: Peak Pressure		
Impulse Energy		
Underground: Peak Pressure		
Impulse		
Energy		
· ·		

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Molecular Weight: Comparition: % 270 Oxygen Belence: CO<sub>2</sub> % CO % Tetryl 75 -54 -12 int 25 Density: gm/cc Cast 1.59 Melting Point: "C 68 C/H Ratio Freezing Point: "C Impest Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg Boiling Point: "C 28 Refrective Index, na 10 17 na n, Friction Pendulum Test: **Vocuum Stability Test:** Stuel Shoe Cracks cc/40 Hrs, at 90°C Fiber Shoe Unaffected 100°C 3.0 Rifle Bullet Impact Test: Trials 120°C 11+ % 0 135°C Explosions 150°C Partials 30 Burned 0 200 Gram Bomb Sand Test: **Unaflected** 70 Sand, gm 53.7 Ex; insian Temperature: Sensitivity to Initiation: ۰C Minimum Detonating Charge, gm Econds, 01 (no cap used) Mercury Fulminate 0.23\* 1 5 Ignites 310 Lead Azide 0.19\* 10 \*Alternative initiating charges. 15 Bellistic Morter, % TNT: (a) 122 20 Trau.1 Test, % TNT: 75°C International Heat Test: Plate Dent Test: (b) % Loss in 48 Hrs Method в В Condition Cast Cast 100°C Heet Test; Confined No Yec % Loss, 1st 48 Hirs 1.66 1.62 Density, gm/cc % Loss, 2nd 48 Hrs 118 Brisance, % TNT 114 Explosion in 100 Hrs Dete nation Rate: Flammability Index: Will not continue to burn Confinement None Condition Cast Hyproscopicity: % 0.03 Charge Diameter, in. 1.0 Density, gm/cc 1.60 Veletility: Rate, meters/second 7**3**85

Tetrytol, 75/25

AMCP 706-177

#### AMCP 706-177

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#### Tetrytol, 75/25

Fregmentation Test:		Sheped Charge Effectiveness, TNT =	100:
-			
• • •		1	Cones (d)
	•••		
Charge Wt, Ib	2.101	Hole Depth IZV	
Total No. of Fragments:			
For TNT	703	Light yell	LOW to burr
For Subject HE	857	Belevit Manage Descriptions	· · · · · · · · · · · · · · · · · · ·
3 inch HE, M42A1 Projectile, Let KC-5:		Fracipei Gana: Bursters, demois	LUON DIOCES
Density, gm/cc	1.60		
Charge Wt, Ib	0.845		
Total No. of Fragmonts:		Mahad of Looding	
For TNT	514		
For Subject HE	591		
		Loading Density: gm/cc	1.59
Fregment Velocity: ft/sec			
At 25% ft	•	Storage:	
Density, gm/cc	Il Projectile, Lee WC-91:       Glass Cones       Steel Cones       (d)         Cc       1.39       Hole Volume       127         Hole Depth       120         Fregmensts:       703         t HE       857         Al Projectile, Lee KC-3:       Color:       Light yellow to buff         cc       1.60         b       0.845         messests:       Site Solution         ft/sec       Storage:         Method of Leading:       Cast         Leading Density: gm/cc       1.59         iff/sec       Storage:         Method       Dry         Howard Class (Quantity-Distonce)       Class 9         Compatibility Group       Group I         Exudation       Exudes at 65°C         Ditectic Temperature, °C:       67.5         gr Tetryl 100 gm TNT       100         Wax, in. for 50% Detonation       1.66         Densitiv, gm/cc       1.66		
		Method	Dry
Blast (Relative to TNT):		Hazard Class (Quantity-Distance)	Class 9
Air:	X	Compatibility Group	Group I
		Considerations	Denides at 6500
_ •		Exuagrich	Exudes at 05-t
Energy			
Air, Confined:		Eutectic Temperature, <sup>o</sup> C:	67.5
Impulse		gr Tetryl/100 gm TNT	
Hadaa Mataa		67.5°C	54-82
Fook Pressure		Booster Sensitivity Test:	(c)
Impulse			
Energy			
<b></b>		Wax, in. for 50% Detonation	1.65
Vederground: Peak Pressure		Density, gm/cc	1.66
impulse	Density, gm/cc     1.39       Charge Wt, Ib     2.101       Tetel Ne. of Fregments:     For TNT       For Subject HE     857       Density, gm/cc     1.60       Charge Wt, Ib     0.845       Tetal Ne. of Fregments:     For Subject HE       For Subject HE     591       Leading Density: gm/cc     Storage:       meansity, gm/cc     Method       at 25½ ft     Storage:       Density, gm/cc     Method       at Release     Exudation       Erargy     Exudation       Density: gm/cc     Butectic Temperature, <sup>0</sup> C;       gmeant Velocity: ft/sec     Goster Sensitivity Test:       Marhod     Hozard Class (Quantity-Distoration       Erargy     Exudation       Distectic Temperature, <sup>0</sup> C;     gr Tetryl/100 gm ThT       Fook Pressure     Booster Sensitivity Test:       Impulse     Condition       Erargy     Hozard Class (Duantity Distoration)       Peak Pressure     Density, gm/cc		
Energy			ļ
Energy			
Energy			
Energy			

Tetrytol, 70/30

AMCP 706-177

Composition:		Molecular Weight:	266
96 Tabuur	70	Oxygen Bolence;	
Tetryl	70	CO. %	-55
TNT	30	CO %	-13
		Density: gm/cc Cast	1.60
		Melting Point: *C	68
C/H Ratio		Freezing Point: °C	
Impact Sassitivity, 2 Kg Wt:		Boiling Point: *C	
Bureau of Mines Apparatus, cm Sample Wt 20 mg	28	Refrective Index, no	
Picatinny Arsenal Apparatus, in.	11	-	
Sample Wt, mg	18	n <sub>2s</sub>	
		n <sub>20</sub>	
Friction Pondulum Test:		Vecuum Stebility Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	
Rifie Bullet Ir :poct Test: Trials			3.2
•		120°C	11+
% Explosions 0		135°C	
Partials 55		150°C	
Burned 0			
Unaffected 45		200 Gram Bomb Sand Text:	53.2
Unamerica +)	· <u>···</u> ·······························	Sand, gm	
Explosion Temperature: *C		Sensitivity to Initiation:	
Seconds, 0.1 (no cop used) 416		Minimum Detonating Charge, gm	
1 387		Mercury Fulminate	0.23*
5 Ignites 320		Leod Azide	0.22*
10 302		*Alternative initiating charges	
15 289		Bellistic Morter, % TNT: (a)	120
20 275		Treuzi Test, % TNT:	
75°C International Hoat Tast:		Plete Dent Test: (b)	
% Loss in 48 Hrs		Method	в
	<u> </u>	Condition	Cast
100°C Heet Test:		Confined	Yes
% Loss, 1st 48 Hrs	0.1	Density, gm/cc	1.60
% Loss, 2nd 48 Hrs	0.1	Brisance, % TNT	117
Explosion in 100 Hrs	None		••;
Hammebility Index: Will not co	ntinue to hum	Detenation Rate: Confinument	¥
will not co	nerune co para		None
Hygroscopicity: %	0.02	- Conditicr	Cast
······································	0	Charge Dirignater, in.	1.0
Volotility:	·····	Density, gm/cc	1.60
T WINTING Y (		Rote, meters/second	7340

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#### AMCP 706-177

**C**urrier E

Tetrytol, 70/30

Fregmentation Test:		Shoped Charge Effectiveness, TNT = 10	0:
90 mm HE, M71 Projectile, Lot WC-9	<b>)1:</b>	Glass Cones Steel C	pnes
Density, gm/cc	1.60	Hole Volume	
Charge Wt, Ib	2.090	Hole Depth	
Total No. of Fragments:		Color:	low to Luff
For TNT	703	Line and the	
For Subject HE	840	Principel Uses: Bursters, demolit	ion blooks
3 inch HE, M42A1 Projectile, Lot KC-	5:		
Density, gm/cc	1.60		
Charge Wt, Ib	0.842		
Total No. of Fragments:		Method of Looding:	Cast
For TNT	514		
For Subject HE	585	Looding Density: gm/cc	1.60
Fregment Velocity: ft/sec At 9 ft At 25½ ft		Storege:	
		Juorage:	
Density, gm/cc		Method	Dry
Blast (Relative to TNT):		Hazard Class (Quentity-Listance)	Class 9
Air: Peak Pressure		Compatibility Group	Group I
Impulse		Exudation Exud	es at 65°C
Energy			
Air, Confined: Impulse			
Under Weter: Peak Pressure			
Impulse			
Energy			
Underground: Peak Pressure			
Impulse			1
Energy			

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AMCP 706-177 Tetrytol, 65/35 Molecular Weight: 264 Composition: 95 Oxygen Belence: CO<sub>2</sub> % CO % 65 Tetryl -56 -14 TNT 35 1.60 Density: gm/cc 68 Melting Point: "C Freezing Point: °C C/H Ratio Impact Sensitivity, 2 Kg Wt: **Boiling Point: "C** Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg 28 Refrective Index, na 11 n<sub>25</sub> 17 n,0 Friction Pendulum Test: Vecuum Stability Test: cc/40 Hrs, at 90°C Steel Shoe Cracks Fiber Shoe Unaffected 100°C 2.8 Rifle Bullet Impact Test: Trials 120°C 11+ % 0 135°C Explosions 150°C Partials 10 Burned 0 200 Grem Bomb Sand Test: Unaffected 90 Sand, gm 52.6 **Explosion Temperature:** °C Sensitivity to Initiation: Seconds, 0.1 (no cap used) Minimum Detonating Charge, gm Mercury Fulminote 0.23\* l 5 Ignites 325 0.23\* Lead Azide 10 \*Alternative initiating charges. 15 Ballistic Mortar, % TNT: 20 Trauzi Test, % TNT: 75°C International Heat Test: Plate Dest Test: % Loss in 48 Hrs Method Condition 100°C Heat Test: Confined % Loss, 1st 48 Hrs Density, gm/cc % Loss, 2nd 48 Hrs Brisonce, % TNT Explosion in 100 Hrs **Detonation Rate:** Flammebility index: Will not continue to burn None Confinement Condition Cast 0.02 Hygroscopicity: % Charge Diameter, in. 1.0 Density gm/cc 1.60 Velatility: Rate, meters/second 7310

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AMCP 706-177

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#### Tetrytol, 65/35

Fregmentation Test:		Shaped Charge Effectiveness, TNT = 10	<b>DO:</b>
		(d) (e) Glass Cones Steel C	
90 mm HE, M71 Projectile, Let WC-91:	1.61	Hole Volume 133 126	
Density, gm/cc Charge Wt, Ib	2.010	Hole Depth 120 110	
Charge W1, 10	2.020		•
Total No. of Fragments:		Celor:	<u> </u>
For TNT	703	Light yellow	to buff
For Subject HE	856		<u> </u>
		Principel Uses: Bursters, demoliti	or blocks
3 inch HE, M42A1 Projectile, Let KC-3:			
Density, gm/cc	1.60 0.845		
Charge Wt, Ib	0.047	1	
Tetal No. of Fragmants:			<b>A</b>
For TNT	514	Method of Londing:	CP **
For Subject HE	585		
-		Londing Density: gm/cc	1.60
Fregment Velocity: ft/sec			
At 9 ft			
At 251/2 ft		Storoga:	
Density, gm/cc		Method	Dry
		merico	Ltty
liest (Relative to TNT):		Hazard Class (Quantity-Distance)	Class 9
	X		
Ain		Compatibility Group	Group I
Peak Pressure		Exudation Exud	les at $65^{\circ}$ C
Impulse			168 WC 07 G
Energy			
Air, Confined:			
Impulse			
Under Water: Peak Pressure			
Impulse			
Energy			
		1	
Underground:			
Peak Pressure			
Impulse			
Energy			

#### Tetrytol, 80/20, 75/25, 70/30, 65/35

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#### Compatibility with Metals:

Dry: Copper, brass, aluminum, magnesium, stainless steel, mild steel, mild steel coated with acid proof black paint and mild steel plated with copper, cadmium, zinc or nickel are unaffected. Magnesium-aluminum alloy is slightly affected.

<u>Wet:</u> Stainless steel and mild steel coated with scid-proof black paint are unaffected. Copper, brass, aluminum, magnesium, magnesium-aluminum alloy, mild steel and mild steel plated with cadmium, copper, zinc or nickel are slightly affected.

#### Preparation:

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Tetrytols are manufactured by heating TNT in a melting kettle, equipped with a stirrer, until all the TNT is melted. The necessary amount of tetryl is added and heating and stirring are continued. The tymperature is allowed to drop from  $100^{\circ}$ C until the mixture is of maximum viscosity suitable for pouring. Part of the tetryl dissolves in TNT forming a eutoctic mixture which contains 55 percent tetryl. This mixture freezes at 67.5°C.

#### Origin:

Tetrytols were developed during World War II. The 70/30 tetryl/TNT castable mixture is the most important in military applications.

#### References: 74

(a) L. C. Smith an., E. G. Evster, Physical Testing of Explosives, Part III, Miscellaneous Sensitivity Tests, Performance Tests, OSRD Report No. 5746, 27 December 1945.

(b) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 503, 11 August 1942.

(c) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> <u>Tetryl in Boosters</u>, NOL Memo 10,303, 15 June 1949.

(d) Eastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Sec III, Variation of <u>Cavity Effect with Explosive Composition</u>, NDRC Contract W5/2-ORD-5723.

(e) Eastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Final Report, Eastern Lab, du Pont, 18 September 1943, NDRC Contract W-672-ORD-5,23.

(f) Also see the following Picatinny Arsenal Technical Reports on Tetrytol:

<u>o</u>	<u>1</u>	2	<u>3</u>	5	6	<u>7</u>	8	2
1260 1360 1420 1500 1530	1291 1311 1451 1651 1951	1372	1193 1213 1363 1493	1285 1325 1885 2125	1376 1436 1466 1506	1477 1737 1797	1158 1388 18 <b>38</b>	1379

<sup>74</sup>See footnote 1, page 10.

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#### TNT (Trinitrotoluene)

Composition:		Molecular Weight: (C.	7 <sup>H5N306</sup> )	2	27
с 37.0 сн	2	Oxygen Balance:			-1
1		CO <sub>2</sub> %			74 25
н 2.2 <sub>ор</sub> и-т	<u>_No</u> 2				
N 13.5		Density: gm/cc	Crystal	1	.65
0 42.3		Melting Point: °C		9:	l
C/H Ratio 0.549	2	Freezing Point: "C			
Impact Sansitivity, 2 Kg Wt:		Beiling Point: "C			
Bureau of Mines Apparatus, cm Sample Wt 20 mg	95-190+	Refrective Index, na		a 1	5430
Picatinny Arsenal Apparatus, in.	14-15			-	.6742
Sample Wt, mg	17				717
Friction Pendulum Test:		Vecuum Stebility Test:	. i		
Steel Shoe U	naffected	cc/40 Hrs, at			
	naffected	90°C			
		- 100°C		0	. 10
Rifle Bullet Impoct Test: Trials		120°C		0	.23
<b>%</b>		135°C		0	44
Explosions 4		150°C		0	.65
Partials 0					
Burned 0		200 Gram Bomb Sand To	est:	1.1	B.0 4
Unaffected 6		Sand, gm			
Explosion Temperature: °C		Sensit:vity to Initiation:			
Seconds, 0.1 (no cap used) 570		Minimum Detonating	Charge, gm		
1 520 5 Decomposes 475		Mercury Fulminate		0	.24*
		Leod Azide		0	. 27*
<b>10</b> 465		Tetryl *Alternative initia	uting cher	789	
15		Bellistic Morter, % TN		Std=1	
20				Stdrift	
75°C International Heat Test:		Trauzi Test, % TNT: Plate Dent Test:	(a)		~~
% Loss in 48 Hrs	0.04	Method	A A		B
		Condition	Cast Pi		Cast
100°C Heet Test:		Confined	Yes Yes		No
% Loss, 1st 48 Hrs	0.2	Density, gm/cc	1.61 1.		1.61
% Loss, 2nd 48 Hrs	0.2	Brisance, % TNT	100 100		100
Explosion in 100 Hrs	None				
Flammability Index: (b)	100	- Detonation Rate: Confinement	Unconf:	ined a	Jnconfin
		- Condition	Presse		Cast
Hygrescepicity: % 30°C, 90% RH	0.03	Charge Diameter, in.			1.0
		<ul> <li>A second s</li></ul>	<b>1</b>		
		- Density, gm/cc	1.56		1.56

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TNT (Trinitrotoluene)

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				())	(.)
Booster Sensitivity Test: Condition	(c) Pressed	Cast	Decomposition Equation: Oxygen, atoms/sec	(h) 10 <sup>11.4</sup>	(i) 10 <sup>12.2</sup>
_	100	100	(Z/sec)	10	10
Tetryl, gm			Heat, kilocalorie/mole	34.4	43.4
Wax, in. for 50% Deton	ation 1.00	0.82	(JH, kcal/mol)		
Wax, gm		- 1-	Temperature Range, °C	275-310	230-277
Density, gun/cc	1.55	1.50	Phase	Liquid	Liquid
Heet of:	(a)	<u> </u>			
Combustion, cal/gm		3620	Armor Plate Impact Test:		
Explasion, cal/gm		1080	60 mm Morter Projectile:		(1)
Gas Voiume, cc/gm		730	50% Inert, Velocity, ft	sec	>1100
Formation, cal/gm		78.5	Aluminum Fineness		•
Fusion, cal/gm Temperature, °C		22.34 79	500-16 General Purpose Be		(5)
Specific Heet: cal/gm/*C	····				(3)
		0.309	Plate Thickness, inches	Trials	<u>% Iner</u>
20		0.328	<b>j</b> .	0	
50		0.353	11.	õ	
8 <b>0</b>		0.374		1	100
			11,2 13,_	4	50
			Bemb Drop Test:		
Thermal Conductivity: cal/sec/cm/°C	See next p	age.	Bomb Drop Test: 17, 2030-Ib Semi-Armer P	iercing Tamb	vs Concrete
cal/sec/cm/°C		age.	-	•	<b>vs Concrete</b> 00-6000
cal/sec/cm/°C Coefficient of Expansion: Linear, %/°C -40 <sup>0</sup> to	(b) 60°C 5.4 x	10 <sup>-5</sup> (b)		50	00-6000
cal/sec/cm/°C Coefficient of Expension: Linear, %/°C =40° to =40° to	(b) 60°C 5.4 x 60°C 6.7 x	10 <sup>-5</sup> (b) 10 <sup>-5</sup>	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft	50	00-6000
cal/sec/cm/°C Coefficient of Expension: Linear, %/°C =40° to -40° to Volume, %/°C 27° to	(b) 60°C 5.4 x 60°C 6.7 x 80°C 16 x	$10^{-5}$ (b) $10^{-5}$ $10^{-5}$ (b)	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft	50 omb vs Concr	00~6000 Me:
col/sec/cm/°C Coefficient of Expectation: Lineor, %/*C -40° to -40° to Volume, %/*C 27° to 16° to	(b) 60°C 5.4 x 60°C 6.7 x 80°C 16 x 70°C 26.3	$10^{-5}$ (b) $10^{-5}$ (b) $x 10^{-5}$ (b)	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft 500-Ib General Purpose Be	50 mb vs Cencr <u>No Seal</u>	00-6000
col/sec/cm/°C Coefficient of Expectation: Lineor, %/*C -40° to -40° to Volume, %/*C 27° to 16° to	(b) 60°C 5.4 x 60°C 6.7 x 80°C 16 x	$10^{-5}$ (b) $10^{-5}$ $10^{-5}$ (b)	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft 500-Ib General Purpose Bo Height, ft	50 <u>No Seal</u> <u>4,000</u>	00-6000 No: Ses1 4-5,000
col/sec/cm/°C Coefficient of Expension: Linear, %/°C -40° to -40° to Volume, %/°C 27° to 16° to Hardness, Mahs' Scele:	(b) 60°c 5.4 x 60°c 6.7 x 80°c 16 x 70°c 26.3 (e)	$10^{-5}$ (b) $10^{-5}$ (b) $x 10^{-5}$ (b)	T7, 2030-Ib Semi-Armer P Max Sofe Drop, ft S00-Ib General Purpose Bi Height, ft Trials	50 <b>omb vs Cencr</b> <u>No Seal</u> 4,000 26	00-6000 **: <u>Seal</u> 4-5,000 20
col/sec/cm/°C Coefficient of Expension: Linear, %/*C =40° to -40° to Volume, %/*C 27° to 16° to Herdness, Mohs' Scale: Your-' Medulus:	(b) $60^{\circ}C 5.4 \times 50^{\circ}C 6.7 \times 30^{\circ}C 16 \times 70^{\circ}C 26.3$ (e) (b)	$10^{-5}$ (b) $10^{-5}$ (b) $x \ 10^{-5}$ (b) $x \ 10^{-5}$ (c) 1.4	T7, 2030-Ib Semi-Armer P Max Safe Drop, ft S00-Ib General Purpose Bi Height, ft Trials Unaffected	50 <b>mb vs Cenc</b> <u>No Seal</u> 4,000 26 24	00-6000 <u>Seal</u> 4-5,000 20
cal/sec/cm/°C Coefficient of Expension: Linear, %/°C =40° to -40° to Volume, %/°C 27° to 16° to Herdness, Mohs' Scale: Yeur-' Madulus: E', uynes/cm <sup>2</sup>	(b) $60^{\circ}c 5.4 \times 60^{\circ}c 6.7 \times 80^{\circ}c 16 \times 70^{\circ}c 26.3$ (e) (b)	$10^{-5}$ (b) $10^{-5}$ (b) $\times 10^{-5}$ (c) 1.4 $5.45 \times 10^{10}$	T7, 2030-Ib Semi-Armer P Max Safe Drop, ft 500-Ib General Purpose Bi Height, ft Trials Unaffected Low Order	50 50 50 50 50 50 50 50 50 50	00-6000 <b>Ses1</b> 4-5,000 20 20 0
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40 <sup>0</sup> to -40 <sup>0</sup> to Volume, %/°C =27 <sup>0</sup> to 16 <sup>0</sup> to Nordness, Mohs' Scale: Yeu=-' Medulus: E', uynes/cm <sup>2</sup> E, lb/inch <sup>2</sup>	(b) $60^{\circ}c 5.4 \times 60^{\circ}c 6.7 \times 80^{\circ}c 16 \times 70^{\circ}c 26.3$ (e) (b)	$\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{1.4}$ 5.45 x 10 <sup>10</sup> 0.79 x 10 <sup>6</sup>	T7, 2030-Ib Semi-Armer P Max Safe Drop, ft 500-Ib General Purpose Bi Height, ft Trials Unaffected Low Order	50 50 50 50 50 50 50 50 50 50	00-6000 <b>Ses1</b> 4-5,000 20 0 0
cal/sec/cm/°C Coefficient of Expension: Linear, %/°C =40° to -40° to Volume, %/°C 27° to 16° to Herdness, Mohs' Scale: Yeur-' Madulus: E', uynes/cm <sup>2</sup>	(b) $60^{\circ}c 5.4 \times 60^{\circ}c 6.7 \times 80^{\circ}c 16 \times 70^{\circ}c 26.3$ (e) (b)	$10^{-5}$ (b) $10^{-5}$ (b) $\times 10^{-5}$ (c) 1.4 $5.45 \times 10^{10}$	T7, 2030-Ib Semi-Armer P Max Safe Drop, ft 500-Ib General Purpose Bi Height, ft Trials Unaffected Low Order High Order	50 50 50 50 50 50 50 50 50 50	00-6000 se: <u>Ses1</u> 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to -40° to Volume, %/°C =27° to 16° to Mardness, Mohs' Scale: Your-' Medulus: E', synes/cm <sup>2</sup> E, Ib/inch <sup>2</sup> Density, gm/cc	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b)	$\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{1.4}$ (b) 1.4 5.45 x 10 <sup>10</sup> 0.79 x 10 <sup>6</sup> 161	T7, 2030-Ib Semi-Armer P Max Safe Drop, ft 500-Ib General Purpose Bi Height, ft Trials Unaffected Low Order High Order	50 50 50 50 50 50 50 50 50 50	00-6000 se: <u>Ses1</u> 4-5,000 20 0 0 0
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to -40° to Volume, %/°C =27° to 16° to Mardness, Mohs' Scale: Your-' Madulus: E', Jynes/cm <sup>2</sup> E, Ib/inch <sup>2</sup> Density, gm/cc Compressive Strongth: Ib/in	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b)	$\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{1.4}$ 5.45 x 10 <sup>10</sup> 0.79 x 10 <sup>6</sup> 161 0-14000	T7, 2030-Ib Semi-Armer P Max Safe Drop, ft 500-Ib General Purpose Be Height, ft Trials Unaffected Low Order High Order 1000-Ib General Purpose B	50 50 50 50 50 50 50 50 50 50	00-6000 se: <u>Ses1</u> 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to -40° to Volume, %/°C =27° to 16° to Mardness, Mohs' Scale: Your-' Medulus: E', synes/cm <sup>2</sup> E, Ib/inch <sup>2</sup> Density, gm/cc	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b)	$\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{1.4}$ (b) 1.4 5.45 x 10 <sup>10</sup> 0.79 x 10 <sup>6</sup> 161	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft S00-Ib General Purpose Bi Height, ft Trials Unaffected Low Order High Order 1000-Ib General Purpose B Height, ft	50 50 50 50 50 50 50 50 50 50	00-6000 se: <u>Seal</u> 4-5,000 20 20 0 0 se: <u>Seal</u> 5,000
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to -40° to Volume, %/°C =27° to 16° to Mardness, Mohs' Scale: Your-' Madulus: E', Jynes/cm <sup>2</sup> E, Ib/inch <sup>2</sup> Density, gm/cc Compressive Strongth: Ib/in	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b)	$10^{-5} (b)$ $10^{-5} (b)$ $x 10^{-5} (b)$ $x 10^{-5} (c)$ $1.4$ $5.45 \times 10^{10}$ $0.79 \times 10^{6}$ $161$ $0-14000$ $1.62$	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft S00-Ib General Purpose Bi Height, ft Trials Unaffected Low Order High Order 1000-Ib General Purpose D Height, ft Trials	50 50 50 50 50 50 50 50 50 50	00-6000 <b>Seal</b> 4-5,000 20 0 0 0 0 0 0 0 0 26
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to =40° to Volume, %/°C =27° to 16° to Mardness, Mohs' Scale: Yeur-' Madulus: E', Jynes/cm <sup>2</sup> E, Ib/inch <sup>2</sup> Density, gm/cc Compressive Strongth: Ib/in Density, gm/cc Yaper Pressure: °C mm	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b) mch <sup>2</sup> 1380 Mercury	$\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{10^{-5}}$ (b) $\frac{10^{-5}}{1.4}$ 5.45 x 10 <sup>10</sup> 0.79 x 10 <sup>6</sup> 161 0-14000	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft S00-Ib General Purpose Ba Height, ft Trials Unaffected Low Order High Order 1050-Ib General Purpose B Height, ft Trials Unaffected	50 50 50 50 50 50 50 50 50 50	00-6000 <b>Seal</b> 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to =40° to Volume, %/°C =27° to 16° to Hardness, Mohs' Scale: Yeum-' Madulus: E', Jynes/cm <sup>2</sup> E, Ib/inch <sup>2</sup> Density, gm/cc Compressive Strongth: Ib/in Density, gm/cc Veper Pressure: °C mm 50	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b) Mercury 0.042	$10^{-5} (b)$ $10^{-5} (b)$ $x 10^{-5} (b)$ $x 10^{-5} (c)$ $1.4$ $5.45 \times 10^{10}$ $0.79 \times 10^{6}$ $161$ $0-14000$ $1.62$	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft S00-Ib General Purpose Bi Height, ft Trials Unaffected Low Order High Order 1060-Ib General Purpose B Height, ft Trials Unaffected Low Order	50 50 50 50 50 50 50 50 50 50	00-6000 Seal 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to -40° to Volume, %/°C =27° to 16° to Herdness, Mohs' Scele: Your-' Medulus: E', synes/cm² E, Ib/inch² Density, gm/cc Compressive Strength: Ib/in Density, gm/cc Vepor Pressure: °C mm 80 85	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b) Mercury 0.042 0.053	$10^{-5} (b)$ $10^{-5} (b)$ $x 10^{-5} (b)$ $x 10^{-5} (c)$ $1.4$ $5.45 \times 10^{10}$ $0.79 \times 10^{6}$ $161$ $0-14000$ $1.62$	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft S00-Ib General Purpose Bi Height, ft Trials Unaffected Low Order High Order 1060-Ib General Purpose B Height, ft Trials Unaffected Low Order	50 50 50 50 50 50 50 50 50 50	00-6000 Seal 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0
col/sec/cm/°C Coefficient of Expension: Lineor, %/°C =40° to -40° to Volume, %/°C =27° to 16° to Nordness, Mohs' Scale: Your-' Medulus: E', synes/cm² E, lb/inch² Density, gm/cc Compressive Strength: lb/in Density, gm/cc Yapor Pressure: °C mm 80 85 90	(b) 60°C 5.4 x 50°C 6.7 x 80°C 16 x 70°C 26.3 (e) (b) Mercury 0.042	$10^{-5} (b)$ $10^{-5} (b)$ $x 10^{-5} (b)$ $x 10^{-5} (c)$ $1.4$ $5.45 \times 10^{10}$ $0.79 \times 10^{6}$ $161$ $0-14000$ $1.62$	T7, 2030-Ib Semi-Armer-P Max Safe Drop, ft S00-Ib General Purpose Bi Height, ft Trials Unaffected Low Order High Order 1060-Ib General Purpose B Height, ft Trials Unaffected Low Order	50 50 50 50 50 50 50 50 50 50	00-6000 Seal 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0

#### AMCP 706-177

#### INT (Trinitrotoluene)

	· · · · · · · · · · · · · · · · · · ·		_
Frequentation Test:	£ <sup>*</sup>	Shaped Chorge Effectiveness, TNT = 100:	
90 ram HE, M71 Projectile, Let WC-91;		Gécus Cones Steel Cones	
Density, gm/cc	1.60	He e Volume 100 100	
Charge Wt, Ib	2.104	Hole Depth 100 100	
	1		
Tatal No. of Fragments:	703	Celer: Light yellow	
For TNT	103		
For Subject HE	103	Principal Uses: GP bombs, PE projectiles,	
3 inch HE, M42A1 Projectile, Let KC-5:	a de la companya de l	demolition charges, depth charges, grenades, propeliant compositions	
Density gm/cc	1.60	grenader, propertant compositions	
Charge Wt, Ib	0.848		
	4		
Total No. of Frequents:		Nuthed of Lending: 1. Cast	
For TNT	514	2. Pressed	
For Subject HE	314		
санананан каланан калан Каланан каланан	~~~~~	Loading Density: gm/cc See below	
Fragment Velocity: ft/sec	(k)		
At 9 fr At 251/2 ft	23.0	Storage:	
Density, gm/cc	1.58		
		Method Dry	
Slast (Kelative to TNT):		Hazard Class (Juantity-Distance) Class 9	
01035 35,0000100 AD 104122			
Ain		Compatibility Group Group I	
Peak Pressure	100	59a	
Impulse	100	Exudation None at 65°C	
Energy	100		
Air, Confine		Loading Density: gm/cc	
Impulse	100	1. Cast 1.58-1.59 2. Pressed psi x 10 <sup>3</sup>	
Under Water: Peak Pressure	100	3 5 10 15 20 <b>30</b> 50 1.35 1.40 1.45 1.52 1.55 1.59 1.6	<
	100 100		
Impulse Energy	100	Thermal Conductivity: cal/sec/cm/ <sup>O</sup> C	
Creagy guid	100	-h	
Underground:		Density 1.19 gm/cc (g) 5.28 x 10 1.51 gm/cc (g) 7.12 x 10	
Peok Pressure	100	$1.54 \text{ gm/cc}$ (b) $5.6 \times 10^{-4}$	
Impulse	100	$1.67 \text{ gm/cc}$ (g) $12.21 \times 10^{-4}$	
Energy	100	Viscosity, poises:	
		Tem, 85 <sup>0</sup> C 0.139	
		100 <sup>0</sup> 0 0.095	
		Bulk Mcd. $\alpha$ is at isom <u>Temperature (25<sup>0</sup>-30<sup>9</sup>C):</u> (m)	
		Dynes/cm <sup>2</sup> x 10 <sup>-10</sup> 2.92	
		Densio, gm/cc 1.56	

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	2.	T (Triait	rotoluene	2		
Effect of Temperature on Pate	of Detona	tion: (1	)			
Responsture of Charge, <sup>O</sup> C	-54	ย	60	60		
Sours at Temperature	16	16	24	72		
Density, gm/cc	1.63	1.62	1.64	1.64		
Fate, maters/second	6700	6820	6770	6510		
Sensitivity to Electrostatic	Discharge,	Jouies;	Through 1	00 Meah:		
Unconfine? Confined	0.06 4.4		• •	t tala K	ş	
Impact Assativit, versus Tem	gature:			r		
Picating Arsens] Appareta	s, 2 ng wt nches	, inches:		2 	el es	
_4() Roca 80 90 105-110	17 14 7 3 2 (5 exp	l in 20 t	rials) y		•	
Depact Sensitivity versus Los	ding Motho	d, Larga	Impact Ap	paratus,	Inches:	
Pressed at 1.60 gm/ce Cast at 1-50 gm/cr	70 26			•		
Hifle fullet Dypert Servicivi	ty versus	Tempare tus	re, Confi	Dements	×	
Standard Iron Domb:	1an	R	nom pers ture		<u>105° t</u>	o 110°C
30 Air Hace Trials Explosions		1 very	10 Low order	<b>r</b> *	: •	10 7
Air Space Trisls Explosions			0			10 0
Tin or Cardboard Bombs:	:					
With or Without Air Space Triels Tosions			10			10 U

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ANCP

No. Anna

AHCP 706-177

#### 1NT (Trinitrotolusse)

Aplusion Temperature versus TET Initis' Temperature:

THT Temperature, Initial		Explosion Resperature,	°c
Room 105 <sup>0</sup> -100 <sup>0</sup> C		470 (Decomposes) 480 (Decomposes)	•
Explosion Trapersture versus C	onfinement, <sup>o</sup> C		
Unconfined Sealed in glass capillary	Decomposes Explodes	470 320-335	
Viscosity at 80.5°C:	. *		
Viscosity, X, cp log X = $3 \times 3$ S = $5$ solid in slurry Particle size effect, small	046 s + 2.26		
Density, gr/ce:			
<u>°c</u>	State	gm/cc	

Flaked	1.65
Flaked	1.64
Liquid	1.48
	1.48
Liquid	1.47
	Fiaked Liquid Liquid

Solubility of Ter, gra/100 gra (\$), in: (f)

M	ater	Acat	ione	Be	12020	. S	Tol	Uene
°c	8 <b>1</b> .	°C.	ž	်င္	E State		°C	ž
0 40 40	0.0100 0.0130 0.0285 0.0675	0 20 40 60	57 109 228 600	0 30 40 60 80	13 67 180 478 >2000		0 20 50 80	28 55 130 357 71700
	Carbon achloride	Rti	ber	Chlor	arolo			loro-
<u>°c</u>	<b>£</b> 19	°c	2	<u>°c</u>	2		0,	ź
0 40 60 70	0.30 0.35 1.75 6.90 17.34	0 20	1.73 3.29	0 20 40 60	6 19 66 302		25 55	3. 5 60
76								

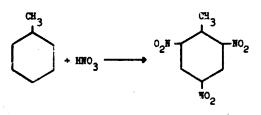
OF 4

ANCE 705-177

			1	T (Trinita	rotoluene)		
Pyrt	dine	Methyl	acetate		hloride	ethy_	chozy- acetate
<u>°c</u>	ž	°c	٤	<u>°c</u>	٤	مر	1
20 40 60 70	140 250 640 1250	20 40 50	73 135 280	20 40 60	34 123 460	20 40 50	29.5 19 96
Tetrac eth	hloro-	· At	<u>iline</u>	Iso ale	cropyl	Eth	nol
<u>°c</u>	٤	°c	٤	°c	5	<u> </u>	٤
20 40 50	18 50 100	10 30 50 70 80	6.1 11.5 29 74 130	20 40 50	0.76 1.96 2.95	0 20 40 60 70	0.62 1.25 2.85 8.4 15
	tyl alcoh	lol	9	arbon dist	ulfide	Chloro	benzene
<u>°</u>		٤	-	<u>'c</u>	2	<u>°c</u>	£
0 20 40 50		0.20 0.61 1.41 2.35	2	6 20 10	9.14 0.44 1.4	20 31 40 50	<b>3</b> 5 51 79 116

Preparation.

(AC 7258, 7259, 7260 - Mitration Kinetics) (Chemistry of Powder and Explosives, Davis)



In clder processes trinitrotoluepe (TNT) was slowly and laboriously nitrated in three stages using successively stronger acids. Today, however, a single stage nitration is possible, in a short time (less than one hour) producing TNT at a cost of a little less than 6¢/lo. In England, a two stage continuous process was developed during World War II; in the first counter cuttent stage, to the was nitrated to the mono stage mononitrotoluene (MNT); in the second stage, also count current, MHE was nitrated to TNT.

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#### TNT (Trinitrotoluene)

It was the British work, on the kinetics of nitration of toluene to TNT, that first pointed out the basic importance to nitration processes of the nitroxyl ion  $(NO_2+)$ , on the one hand, and the role of the bisulfate ion  $(BSO_4-)$  and unionized sulfuric acid on the other. These concepts were successful in explaining the maximum in nitration rate occurring at a sulfuric acid content of 92%. This work, for instance, leads to the following equation for the rate of formation of TNT from DNT:

### $\frac{d (\text{INT})}{dt} = K (\text{HO}_2^+) [K' (\text{HSO}_4^-) + K'' (\text{H}_2^-\text{SO}_4^-)] (\text{INT})$

<u>Incree Stage Process</u>: Toluene (100 gm) is nitrated to the mono derivative by slowly adding a mixture of 294 gm sulfuric acid (sp gr 1.84) and 147 gm nitric acid (sp gr 1.42) to it at  $30^{\circ}-40^{\circ}$ C, with good agitation. Acid addition requires 1-1.5 hour, and stirring at  $30^{\circ}-40^{\circ}$ C is continued 30 minutes longer. The mixture is cooled and the lower layer of spent acid drawn off.

Half the crude mono is dissolved in 109 gm sulfuric acid (sp gr 1.84) with cooling, the solution heated to  $50^{\circ}$ C and a mixture of 54.5 gm nitric acid (sp gr 1.50) and 54.5 gm sulfuric acid (sp gr 1.84) added, under agitation, at such a rate that the temperature is maintained between 90° and 100°C. Acid addition requires 1 hour, and stirring at 90°-100°C is conti ued 2 more hours.

While the dimitration mixture is still at  $90^{\circ}$ C, 145 gm fuming sulfuric acid (oleum containing 15% free SO<sub>3</sub>) is added slowly. A mixed acid of 92.5 gm each mitric acid (sp gr 1.50) and 15% oleum is slowly added, under good sgitation at  $100^{\circ}$ -11  $\rightarrow$  over 12-2 hours. The mixture is stirred at  $100^{\circ}$ -115°C for 2 more hours, cooled, filtered, and the TNT cake broken up and washed with water. The TNT is washed 3-4 times with hot water (85°-95°C) with good agitation. The project can be purified either by recrystallization from alcohol or by washing it with 5 times its weight of 5% sodium bisulfite solution at  $90^{\circ}$ C for  $\frac{1}{2}$  hour with vigorous stirring, washing with hot water until the washings are colorless, and cooling slowly with stirring to granulate the product.

#### Origin:

THT was first prepared in 1863 by Wilbrand (Ann 128, 178), later by belistein and Kuhlberg (Ber 3, 202 (1870) and also Tiemann (Ber 3, 217 (1870), each using different methods of starting materials. It was nearly 30 years later when Hausemann undertook its manufacture on an industrial scale (Z angew Chem, 1891, p. 508; J Chem In<sup>4</sup>, 1891, p. 1028). After 1901 THT began to be used extensively as a military explosive and Germany became the first nation to adopt it as a standard shell filler (1902-1904). During World War 1 all the major powers of the world were using THT, with the quantity used limited only by the available supply of toluene. Prior to World War II the development of synthesic toluene from petroleum made available in the United States, an almost unlimited supply of this raw material. Because of the general suitability of THT for melt-losding and its extensive use in binary and ternary explosive mixtures, THT is considered the most important military explosive known today.

Destruction by Chemical Decomposition:

TWT is decomposed by adding it slowly, while stirring, to 30 times its weight of a solution prepared by dissolving 1 part of sodium sulfide  $(Ne_2S^{-9}H_2O)$  is 6 parts of water.

### References:75

(a) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

<sup>75</sup>See footnote 1, page 10.

### THT (Trinitrotoluene)

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(b) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Sacond Rovision, MAVORD Report No. 87-46, 26 July 1946.

(c) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> <u>Tetryl in Boosters</u>, NOL Nemo 10,303, 15 June 1949.

(d) L. C. Smith and E. H. Eyster, <u>Physical Testing of Eclosives</u>, <u>Part III</u>, <u>Miscellaneous</u> <u>Sensitivity Tosts</u>, <u>Physicance Tests</u>, OSED Report No. 5746, 27 December 1945.

(e) Report AC-2587.

(f) International Critical Tables and various other sources in the open literature.

(g) E. Hutchinson, <u>The Thermal Jensitiveness of Explosives. The Thermal Conductivity of</u> <u>Explosive Materials</u>, AC-2501, First Report, August 1942.

(h) A. J. B. Robertson, Trans Parad Society, <u>44</u>, 977 (1948).

(i) M. A. Cook and M. T. Abegg, "Isothermal Decomposition of Explosives," University of Utah, <u>Ind Eng Chem</u> (June 1956), pp. 1090-1095.

(j) Committee of Div 2 and 8, HDRC, Report on HFL and Tritonal, OSRD No. 5406, 31 July 1945.

(k) R. W. Drake, <u>Fragment Velocity and Panel Penetration of Several Explosives in Situlated Shells</u>, OSRD Report No. 5622, 2 January 1946.

(1) W. J. McGarry and T. W. Stevens, <u>Detonation Rates of the More Important Military</u> Explosives at Several Different Temperatures, PATR No. 2363, November 1956.

(m) W. S. Cramer, "ulk Compressibility Data on Several High Explosives, NAVORD Report No. 4380, 15 September 1976.

(n) Kantrov, Journal of Chemical Industry (Russia) 6, 1929, pp. 1686-1688.

(o) Also see the following Picatinny Argenal Technical Reports on INT:

ي ٩	1	2	3	4	2	6	1	<u>8</u>	2
10	291	132	43	364	65	86	47	118	: 39
30	551	582	83	694	195	266	87	283	249
30 240	731	782	133	874	425	556	507	638	269
350	861	892	273	904	555	666	527	738	319
630	891	972	513	1094	695	956	597	768	389
760	901	1072	643	1104	735	986	707	838	499
810	971	1182	673	1124	805	1046	607	1088	709
120	1041	1192	743	1224	975	1146	817	1098	739
140	1121	1272	853	1284	1145	1276	537	1128	779
170	1311	1292	863	1294	1155	1376	1107	1148	799
260	1391	1342	1063	1304	1225	1446	1147	1158	889
270	1431	1352	1123	1314	1285	1466	1217	1188	929
360	1451	1372	1133	1344	1305	1476	1247	1198	939
400	1491	2402	1193	1414	1315	1556	1307	1228	1039
460	1651	1452	1243	1444	1355	1636	1417	1258	1109
500	1821	1472	1,23	1454	1425	1756	1427	1308	1129

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AP CHARLES

AMCP 706-17	7		THT (1	rinitrotol	uer-)			
<u>e</u>	2	3	<u>14</u>	٤	<u>6</u>	I	<u>8</u>	2
1530 1540 1550 1730 2010 2100 2160	1492 1562 1582 1712 1862	1373 1493 1553 1633 1693 1823 2063 9163	1524 1544 1564 1674 1674 1924 2064 2214	1435 1445 1535 1535 1535 1605 1635 1665 1865 1965 1715 1885 2175	1956 2216	1437 1457 1497 1537 1547 1557 1557 1557 1597 1677 1797 1847 2007 2147 2167	1318 1338 1388 1418 1428 1578 1618 1688 1726 1838 1838 1838 2008 2138 2168	$\begin{array}{c} 11.39\\ 1179\\ 1259\\ 1289\\ 1369\\ 1379\\ 1429\\ 1429\\ 1449\\ 1489\\ 1589\\ 1589\\ 1689\\ 1729\\ 1729\\ 1729\\ 1789\\ 1689\\ 1789\\ 1689\\ 1789\\ 1819$

**S** MAR II

F. .

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		Torpex	AMCP 706-17
Composition: %	<u> </u>	Moleculer Weight:	97
RDX	42	Ozygen Belence:	
		CO, % CO %	-55 -26
TNT	40		1.76-1.81
Aluminum	18		1. (0+1.01
		Molting Point: "C	
C/H Ratio		Freezing Point: "C	
Supert Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm	42	Boiling Point: *C	
Sample Wt 20 mg		Refrective Index, no	
Picatinny Arsenal Apparatus, in. Sample Wt, mg	9	na	
	15	r.0 20	
Friction Pondulum Test:		Vesuum Stability Test:	
Steel Shoe		cc/40 Hrs, at	
Fiber Shoe		90°C	
Rifle Bullet Impact Test: Trials	<u> </u>		
•		120°C	1.0
Suplosions 20		135°C	
Partials 80	5. C	150°C	
Burned 0		200 Grem Bomb Send Tast:	
Unaffected 0		Sond, gm	59.5
Explasion Temperature: °C	<u></u>	Servitivity to Initiation:	
Seconds, 0.1 (no cap used)		Minimum Detonating Charge, gm	
1		Mercury Fulminate	0.18
5 Decomposes 260		Leod Azide	
10		Tetry	
15		Bellistic Morter, % TNT: (a)	138
		Treuzi Teet, % TNT: (b)	164
75°C International Heat Test: % Loss in 48 Hrs		Plate Dent Test: (c)	
		Method	R
100°C Heat Test:		Condition	Cast
% Loss, 1st 48 Hrs	0.00	Confined	No
% Loss, 2nd 48 Hrs	0.10	Density, gm/cc	1.83
Explosion in 100 Hrs	None	Brisence, % TNT	120
Flemmebility Index:	196	Detenstion Rote: (d)	
	130	Confinement	None
Hygrescepicity: % 30°C, 90% RH	0.00	- Condition	Cast
	0.00	Charge Diameter, in.	1.0
Veietility:		Density, gm/cc	1.81
		Rote, meters/second	7495

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Torpex

Veryl, gn105Wex, in. for 50% DetonctionWax, in. for 50% DetonctionWex, in. for 50% DetonctionPlace, kilocaloris/moleWex, gn20Density, gn/cc1.641.81Combustion, col/gn3740Explosion, col/gn1200Gas Volume, cc/gm1200Gas Volume, cc/gm50% Inert, Velocity, fr/secFormatica, col/gn50% Inert, Velocity, fr/secFusion, cai/gm50% Inert, Velocity, fr/secSole is descend Per pase Bambe:pectile Heat: col/gm/*C0.22Density, gm/cc1.82At $15^{\circ}$ C0.24Iteraing Rate: con/sec9.7 x 10^{-14}Inero, %/*C9.7 x 10^{-14}Density, gm/cc1.82Inero, %/*C9.7 x 10^{-5} (b)Volume, %/*C1.38 x 10^{10}E, dynes/cm*9.53 x 10_{10}^{10}E, dynes/cm*9.53 x 10_{10}^{10}E, dynes/cm*1.77Density, gm/cc1.77Density, gm/cc1.77	leaster Sensitivity Test: Condition	(c) Pressed	Casc	Decomposition Equation:	
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Wax, gm20Density, gm/cc1.641.61Hest ef: Combustion, col/gm(a) 3740Explaind, col/gm1800Gas Volume, cc/gm1800Gas Volume, cc/gm1800Fusion, col/gm1800Gas Volume, cc/gm50% Inert, Vélocity, fr/secFormation, col/gm1800Specific Meet: col/grn/*C(b) At - 5°CAt - 5°C0.22Density, gm/cc1.82It is 15°C0.24It is 15°C1.62Collesc/en/*C9.7 x 10°5Density, gm/cc1.62Collesc/en/*C9.7 x 10°5Volume, % /*C1.62Volume, % /*C1.38 x 10°Volume, % /*C1.38 x 10°Density, gm/cc1.77Density, gm/cc1.77Density, gm/cc1.77Height, ft TriaisUnoffected Low OrderLow OrderItight, ft TriaisDensity, gm/cc1.77Height, ft 			,		
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Gas Volume, cc/gmGas Volume, cc/gmGas Volume, cc/gmFormation, cal/gm $50\%$ Inert, Velocity, ff/secFusion, cal/gm $50\%$ Inert, Velocity, ff/secSpecific Heat: cal/gm/*C $0.22$ Density, gm/cc $1.82$ At $15^{\circ}$ C $0.24$ Density, gm/cc $1.82$ At $15^{\circ}$ C $0.24$ Density, gm/cc $1.82$ Image Rate: cm/sec $1.42$ Confiscion of Expansion: Lineor, %c/*C $9.7 \times 10^{-14}$ Volume, %c/*C $9.7 \times 10^{-14}$ Volume, %c/*C $1.82$ Volume, %c/*C $1.82$ Volume, %c/*C $1.62$ Volume, %c/*C $1.32 \times 10^{-5}$ (b)Volume, %c/*C $1.77$ Fermatics: (b) $1.38 \times 10^{10}$ E, dynes/cm* $1.38 \times 10^{10}$ E, bl/inch* $1.77$ Compressive Strength: (b) $1.77$ Compressive Strength: (b) $1.77$ Venestive, gm/cc $1.77$ Vapor Pressure: $1.77$					
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South General Parysee Bambs:Specific Heat: col/gm/*C(b)At $-5^{\circ}C$ 0.22Density, gm/cc1.82At $15^{\circ}C$ 0.24At $15^{\circ}C$ 0.24Barning Rate: cm/sec1%Image Conductivity: col/sec/cm/*C(b)Confliction of Expansing: Lineor, %6/*C9.7 x $10^{-14}$ 1.82Confliction of Expansing: Lineor, %6/*C75°C 4.7 x $10^{-5}$ (b)Volume, %/*C9.53 x $10^{10}$ F, ip/inch²Volume, %/*C9.53 x $10^{10}$ Lineor, %6/*CFrankit, ' Markin Scale:1.36 x $10^{10}$ Density, gm/ccCompressive Strength: Ib/inch²1.077Compressive Strength: Ib/inch²1.77Compressive Strength: Ib/inch²1.77Compressive Strength: Ib/inch²1.77Compressive:Low OrderVapor Pressere:Low Order				Aluminum Fineness	
lipscific Neet: col/gm/*C (b)At $-5^{\circ}C$ 0.22Density, gm/cc1.82At $15^{\circ}C$ 0.24At $15^{\circ}C$ 0.24It11/4At $15^{\circ}C$ 0.24Density, gm/cc0.24Density, gm/cc9.7 x $10^{-14}$ Coddectivity: col/sec/cm/*C9.7 x $10^{-14}$ Density, gm/cc1.82Coddicativity: col/sec/cm/*C9.7 x $10^{-14}$ Density, gm/cc1.82Coddicativity: col/sec/cm/*C9.7 x $10^{-5}$ (b)Volume, %/*C -73 to $75^{\circ}C$ 4.7 x $10^{-5}$ (b)Volume, %/*CHeight, ftSendelate: F, dynes/cm*1.36 x $10^{0}$ E, dynes/cm*9.53 x $10^{0}$ E, ib/inch²1.36 x $10^{0}$ Density, gm/cc1.77Density, gm/cc1.77Height, ft TrialsUnoffected Low OrderLow OrderHeight, ft TrialsUnoffected Low OrderDensity, gm/cc1.77Height, ft TrialsDensity, gm/cc1.77Height, ft TrialsDensity, gm/cc1.77Height, ft TrialsDensity, gm/cc1.77Height at the second	Fusion, cal/gm			500 th General Day and Bambar	
At $-5^{\circ}C$ 0.22Plote Thickness, inchesDensity, gm/cc1.821At $15^{\circ}C$ 0.241½At $15^{\circ}C$ 0.241½Burning Rate: cm/sec1.821%Burning Rate: cm/sec1.821%Burning Rate: cm/sec9.7 x $10^{-14}$ 1%Colfscient of Expansing: Lineor, %/*C9.7 x $10^{-14}$ T7. 2000-15 Semi-Armer-Piercing Berab vs CentreCoefficient of Expansing: Lineor, %/*C9.7 x $10^{-5}$ (b)Max Safe Drop, ftVolume, %/*C1.82Max Safe Drop, ftCoefficient of Expansing: Lineor, %/*CUnoffacted Low OrderUnoffacted Lineor, ftVolume, %/*C9.53 x $10^{\circ}$ Density, gm/cc1.36 x $10^{\circ}$ Volume, %/*C1.36 x $10^{\circ}$ 1000-16 Genurel Purpose Bamb vs Cencrete:Veney's Medulue: E, dynes/cm³9.53 x $10^{\circ}$ 1000-16 Genurel Purpose Bamb vs Cencrete:Density, gm/cc1.77Height, ft TrialsDensity, gm/cc1.77Unoffacted Low OrderDensity, gm/cc1.77Unoffacted Low Order	inecific Ment: col/om/*C	(b)	·····	Source Contract For Jose Contact:	
At $15^{\circ}$ C0.2411/4Barning Rate: cm/sec11/411/4Barning Rate: cm/sec11/411/4Barning Rate: cm/sec11/411/4Barning Rate: cm/sec9.7 x $10^{-14}$ 11/6Dernsity, gm/cc9.7 x $10^{-14}$ 17. 2000-15 Sami-Armer-Piercing Bernb vs CancerDernsity, gm/cc1.82Max Sofe Drop, ftCoefficient of Expansing: Linear, %/*C -73 to $75^{\circ}$ C 4.7 x $10^{-5}$ (b)Sol-16 Gassrel Purpese Bamb vs Cancerte:Volume, %/*CHeight, ftTrialsUnaffected Low OrderLinear, % /*C1.38 x $10^{0}$ Volume, %/*C1.38 x $10^{0}$ Density, gm/cc1.77Density, gm/cc1.77Compressive Strength: It-/inch* (b) 2109-2300 Density, gm/cc1000-16 Gasurel Purpese Bamb vs ( encrute:Veper Pressure: Low Order1.77		(-)	0.22	Plote Thickness, inches	
At $15^{\circ}$ C0.2411/4Barning Rate: cm/sec11/411/2Barning Rate: cm/sec11/411/2Thermal Conductivity: cal/sec/em/*C(b)9.7 x $10^{-14}$ 17. 2000-15 Sami-Armer-Piercing Berab vs CancerDensity, gm/cc1.82T7. 2000-15 Sami-Armer-Piercing Berab vs CancerCoefficient of Expansing: Lineor, %/*C -73 to $75^{\circ}$ C 4.7 x $10^{-5}$ (b)Max Sofe Drop, ftVolume, %/*CHeight, ftTriolsUnaffected Low OrderVolume, %/*C1.38 x $10^{0}$ F, dynes/cm <sup>3</sup> 9.53 x $10^{0}$ 1.38 x $10^{0}$ E, ib/inch <sup>3</sup> 1.38 x $10^{0}$ Density, gm/cc1.77Compressive Strength: It-/inch <sup>4</sup> (b)2109-2300 1.77Density, gm/cc1.77Veper Pressure: Low Order	Density, gm/cc		1.82		
Ker Ly C     0.24     1½       Barning Rate: cm/sec     1½       Thermal Conductivity:     (b)       cal/sec/cm/*C     9.7 x 10 <sup>-4</sup> Density, gm/cc     1.82       Coefficient of Exponsing: Linear, %/*C -73 to 75°C 4.7 x 10 <sup>-5</sup> (b)     T7, 2000-Ib Semi-Armer-Piercing Berab vs Centre Max Safe Drap, ft       Volume, %/*C     Height, ft       Young's Medulus:     (b)       E', dynes/cm <sup>2</sup> 9.53 x 10 <sup>10</sup> E', dynes/cm <sup>2</sup> 1.38 x 10 <sup>10</sup> Density, gm/cc     1.77       Compressive Strength: Ib/inch <sup>2</sup> (b)     2100-2300       Density, gm/cc     1.77       Very Pressure:     Low Order			2102		
Barning Rate: cm/sec     1%       Bank Drop Test:     Samb Drop Test:       Thermal Conductivity: cal/sec/cm/*C     9.7 x 10 <sup>-14</sup> 1.82     T7, 2000-ib Semi-Armor-Piercing Bernb vs Centr Density, gm/cc       Coefficient of Expansion: Lineor, %/*C     1.82     Max Safe Drop, ft       Valume, %/*C     Height, ft     Trials       Valume, %/*C     9.53 x 10 <sup>10</sup> 1.38 x 10     Height, ft       F, dynes/cm <sup>2</sup> 1.38 x 10     1000-ib Genurel Purpose Bomb vs Cencrete:       Valume, gm/cc     1.77     Height, ft       Trials     Unaffected     Low Order       Lingh Order     1.77     Height, ft       Trials     Unaffected     Low Order       Values, gm/cc     1.77     Height, ft	Át 15°C		0.24		
Isoming Rate: cm/sec     Samb Drop Test:       Thermal Conductivity:     (b) cal/sec/cm/*C     9.7 x 10 <sup>-14</sup> Density, gm/cc     1.82       Coefficient of Exponsing: Lineor, %/*C -73 to 75°C 4.7 x 10 <sup>-5</sup> (b)     T7, 2000-15 Semi-Armer-Piercing Bernb vs Center       Volume, %/*C -73 to 75°C 4.7 x 10 <sup>-5</sup> (b)     Max Safe Drop, ft       Volume, %/*C     Height, ft       Trials     Unaffected       Low Order     1.38 x 10 <sup>0</sup> F; dynes/cm <sup>2</sup> 9.53 x 10 <sup>10</sup> E, lb/inch <sup>2</sup> 1.38 x 10 <sup>0</sup> Density, gm/cc     1.77       Compreseive Strength: lb/inch <sup>2</sup> (b)     2100-2300       Density, gm/cc     1.77       Height, ft       Trials       Unoffected       Low Order       idight, ft       Trials       Unoffected       Low Order       idight, ft       Trials       Unoffected       Low Order				· ·	
Thermal Conductivity:(b) $9.7 \times 10^{-14}$ col/ssc/cm/*C $9.7 \times 10^{-14}$ T7, 2000-B Semi-Armer-Piercing Bernb vs CenterDensity, gm/cc $1.82$ Max Safe Drop, ftCoefficient of Exponsing: $T5^{\circ}C 4.7 \times 10^{-5}$ (b)S00-B General Purpose Bends vs Concrete:Volume, %/*CHeight, ftTrialsUnaffectedCompressive Medules:(b)E', dynes/cm <sup>2</sup> $9.53 \times 10^{10}$ E', dynes/cm <sup>2</sup> $1.38 \times 10^{\circ}$ Density, gm/cc $1.77$ Compressive Strength: $1b/inch^2$ Density, gm/cc $1.77$ Compressive Strength: $1b/inch^2$ Ity, gm/cc $1.77$ Compressive: $1.77$ Compressive: $1.77$					
Ceefficient of Expansion: Lineor, $%/^{C} -73$ to $75^{\circ}C 4.7 \times 10^{-5}$ (b)Max Safe Drop, ftVolume, $%/^{\circ}C$ Meight, ftVolume, $%/^{\circ}C$ Height, ftValuere, $%/^{\circ}C$ Height, ftValuere, $%/^{\circ}C$ Height, ftValuere, $%/^{\circ}C$ Image: Seele:Valuere, $%/^{\circ}C$ Max Safe Drop, ftS00-1b General Purpose Bomb vs Concrete:Height, ftValuere, $%/^{\circ}C$ Height, ftValuere, $%/^{\circ}C$ Image: Seele:Valuere, $%/^{\circ}C$ Height, ftValuere, $%/^{\circ}C$ Image: Seele:Valuere, $%/^{\circ}C$ Image: Seele:	coi/sec/em/*C	(b) S			b vs Cantr <sup>a</sup>
Kiendiku:     Maine Scele:     Triais       Young's Modulue:     (b)     Unaffected       E', dynes/cm <sup>2</sup> 9.53 x 10 <sup>6</sup> High Order       E, lb/inch <sup>2</sup> 1.38 x 10     1000-16 Genurel Purpose Bamb vs Concrete:       Density, gm/cc     1.77     Height, ft       Compressive Strength:     lb/inch <sup>2</sup> 1.77       Veper Pressure:     Low Order	Coefficient of Expansion: Linear, %/°C -73 to	75°C 4.7 x 1	.0 <sup>-5</sup> (b)		creta:
Hisrifik*       Ministriction         Young's Modulus:       (b)         E', dynes/cm <sup>2</sup> 9.53 x 10 <sup>6</sup> E, lb/inch <sup>2</sup> 1.38 x 10 <sup>6</sup> Density, gm/cc       1.77         Compressive Strength:       lb/inch <sup>2</sup> Density, gm/cc       1.77         Height, ft         Trials         Vaper Pressure:	Volume, %/*C			Height, ft	
Yeung's Modulus:       (b)         E', dynes/cm <sup>3</sup> 9.53 x 10 <sup>10</sup> E, lb/inch <sup>2</sup> 1.38 x 10 <sup>6</sup> Density, gm/cc       1.77         Compressive Strength:       lb/inch <sup>2</sup> (b)         Density, gm/cc       1.77         Wear Pressure:       Low Order         Vear Pressure:       Low Order	fordia Acins Scolo:				
Teang's Medulus:       (b)         E', dynes/cm <sup>3</sup> 9.53 x 10 <sup>6</sup> E, lb/inch <sup>2</sup> 1.38 x 10 <sup>6</sup> Density, gm/cc       1.77         Compressive Strength:       1b/inch <sup>2</sup> (b) 2109-2300         Density, gm/cc       1.77         Veper Pressure:       Low Order					
E', dynes/cm <sup>2</sup> 9.53 x 10 <sup>10</sup> High Order         E, lb/inch <sup>2</sup> 1.38 x 10 <sup>0</sup> 1000-tb Genurel Purpese Bomb vs Concrete:         Density, gm/cc       1.77       Height, ft         Compressive Strength: lb/inch <sup>2</sup> (b) 2109-2300       Trials         Density, gm/cc       1.77         Waper Pressure:       Low Order	'eung's Medulus:	(b)			
E, lb/inch <sup>2</sup> 1.38 x 10°         Density, gm/cc       1.77         Compressive Strength: lb/inch <sup>2</sup> (b) 2109-2300       Height, ft         Density, gm/cc       1.77         Weper Pressure:       Low Order	E', dynes/cm²	9,51	$10^{10}$	Fligh Order	
Density, gm/cc     1.77       Compressive Strength: lb/inch <sup>2</sup> (b) 2109-2300     Trials       Density, gm/cc     1.77       Unoffected       Veper Pressure:     Low Order	E, Ib/inch <sup>2</sup>	1.38	x 10 <sup>0</sup>	1000-th Genural Purnase Bamb in Cas	cente:
Compressive Strength: lb/inch <sup>2</sup> (b) 2109-2300         Trials           Density, gm/cc         1.77         Unoffected           Veger Pressure:         Low Order         1.77	Density, gm/cc				
Density, gm/cc 1.77 Unoffected Veger Pressure: Low Order	Summer for the state of the sta	L. (L) 010		• ·	
Vaper Pressure: Low Order			•		
C mm mercury High Order		A			
	℃ mm M	nercury		High Order	
				······································	

Shaped Charge Effectives n, TNT == 100: Free tion Test: 50/36.5/13.5 **Gloss Cones** Ster! Conet 99 1 m HE, M71 Projectile, Let WC-C1: 145 Density, gm/cc 1.75 Hole Volume 150 2.316 Hole Depth 127 131 Chorge Wt, Ib Total No. of Frag 44. Color: Grey For TNT 703 For Subject HE 891 Principal Uses: Depth charges, bombs 3 Inch HE, M42A1 Projectile, Let KC-5: 1.79 Density, gm/cc Chorge Wt, Ib 0.940 Total No. of Fragme Method of Loading: Cast 514 For TNT For Subject HE 647 1.76-1.81 Loading Density: gm/cc At 25% ft nent Velecity: ft/sec 2960 2000 Storage: Density, gm/cc --Method Dry (e) Hazard (Jioss (Quantity-Distance) Class 9 Bleet (Relative to TNT): Compatibility Group Group I Ain 122 Peck Pressure (Scudation 125 Impulse 146 Energy Effect of Temperature on Impert Sensitivity: Air, Con 1: 116 Impulse PA Ispact Test 2 Kg Wt, inches der Wete 116 Peak Pressure 15 7 8 25 127 Impulse 32 104 153 Energy Viscosity, poises: Peak Pressure **Тещр,** 83<sup>0</sup>С 95<sup>0</sup>С 4.5 2.3 Impulse Energy

Torpex

AMCP 706-177

#### AMCP 706-177

#### Torpes

#### Preparation:

Torpex is manufactured by heating TNT to approximately  $100^{\circ}$ C in a steam-jacketed kettle equipped with a stirrer. Water wet RDX is added slowly to the molten TNT, while mixing and heating, until all the water is evaporated. Aluminum is added and the mixture is stirred until uniform. The mixture is cooled, with continued stirring, until it is suitable for pouring. Torpex can also be made by adding the calculated amount of TNT to Composition B to maintain the desired proportion of RDX/TNT, heating and stirring, and adding 18 percent of aluminum to complete the mixture.

#### Origin:

Turpex, a castable high explosive, was developed in England during World War II for use as a filler in warheads, mines and depth bombs. Several variations in the composition of torpex have been evaluated but the following are those used in reprice munitions:

	Torper 2 unwared	Torpex 2 waxed	15 2 3
	(a)	<b>(</b> b)	(c)
RDX, <b>%</b> INT, <b>%</b>	42 40	41.6 39•7	4 <u>1</u> .4 39•5
Aluminum, \$ Wax, \$	18	18.0 0.7	17.9 0.7
Calcium chloride, \$			0.5

(a) Made from Composition B-2 or 60/40 Cycletol.

(b) Made by the addition of aluminum to Composition B.

(c) Made by the addition of calcium chloride to Torpex 2.

Wax has the undesirable effect of (1) tending to congulate the aluminum, thus giving a less homogeneous and more viscous product, (2) lowering the density of the cast explosive from 1.72-1.75 to 1.05-1.70 for waxed torper, and (3) lowering the compressive strength from 3700 psi to 1970 psi for waxed torper. However, wax is used in service torpex for reasons of safety, since there is evidence that its presence lowers the sensitivity of the explosive to impact as measured by laboratory drop tests and bullet sensitivity tests of small charges (Bureau of Ord Res Memo Rpt No. 24, January 1945).

#### References: 76

(a) Committee of Div 2 and 8, NDRC, <u>Report on HBX and Tritonal</u>, JSRD No. 5406, 31 July 1945.

(b) Philip C. Keenan and Dorothy C. Pipes, <u>Table of Military High Explosives</u>, Second Revision, HAVORD Report No. 87-46, 26 July 1946.

(c) D. P. MacDougall, Methods of Physical Testing, CSRD Report No. 803, 12 August 1942.

L. C. Smith and E. H. Eyster, Physical Testing of Explosives, Part III, Miscellaneous Sensitivity Tests, Performance Tests, OSRD Report No. 5746, 27 December 1945.

76See footnote 1, page 10.

#### Torpe:

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(d) G. H. Messerly, The Ente of Detonation of Various Explosive Compounds, OSRD Report No. 1219, 22 February 1943.

M. D. Hurwitz, The Rate of Detonation of Various Compounds and Mixtures, OSRD Report No. 5611, 15 January 1946.

(e) . Tomlinson, Jr., <u>Blast Effects of Bomb Explosives</u>, PA Tech Div Lecture, 9 April 1940.

(f) Eastern Laboratory. du Pont, <u>Investigation</u> of Cavity Effect, Sec III, Variation of <u>Cavity Effect with Explosive Composition</u>, MIRC Contract W672-ORD-5723.

(6) Also see the following Picatinny Arsenal Technical Reports on Torpex:

<u>o</u>	<u>1</u>	2	ĩ	٤	<u>6</u>	I	<u>8</u>
15 <b>30</b>	1651	12 <b>92</b>	2353	1585 1635 1885 2355	1796	1797	18 <b>36</b>

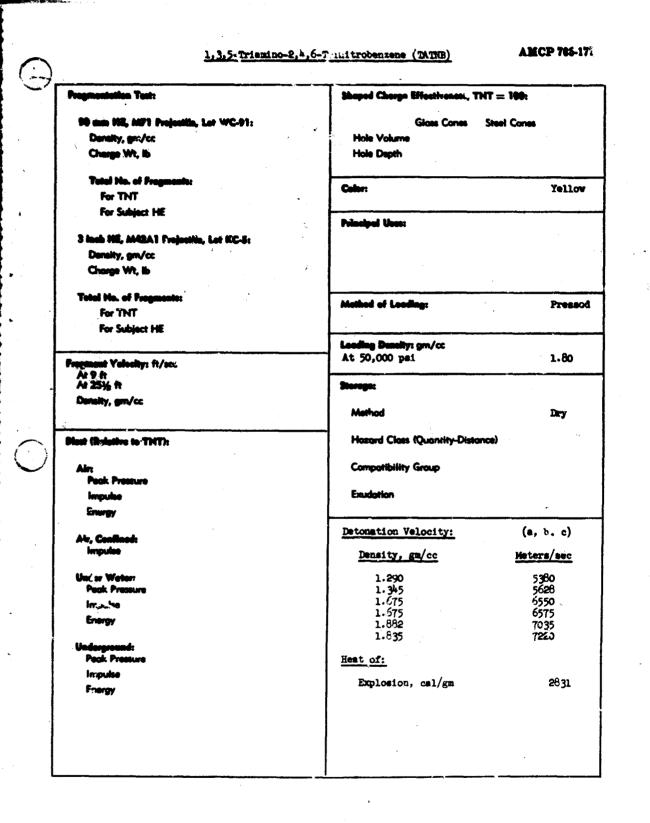
AMCP 706-177

Tax of

### 1,3,5-Triamino-2,4,6-Trinitrobenzens (TATMB)

NH2 NO2 NH2	Oxygen Balence: CO <sub>2</sub> % CO %	-56
		-19
	Gensity: gm/cc Crystal	1.93
NO <sub>2</sub>	Melting Point: *C 330 (b, e)	360 (a)
٤	Freezing Point: *C	
	Boiling Point: *C	
11 7	Refrective kiden, ng, ng, ng,	
	Vecuum Stability Test: cc/40 Hrr, at 90°C	 
	100°C (8, 6)	0.36 
	135°C	
	150°C	
	200 Grain Bomb Sand Test: Sand, gm	42.9
:	Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryl	0, 30
	Bullinia Manager & ThiT.	
	Plate Dent Test: Method	
	Condition	
0.00		
0.00		
None		
	Cu. linement	None
	Condition Charge Diameter, in.	Pressed 0.5
	Dersity, gm/cc	1.80 7 <b>50</b> 0
	21 7 	21     Freesing Point: "C       21     Refrective luder, ng       7     ng       90°C     ng       100°C (a, b)     120°C       135°C     150°C       200 Green Bomb Send Test:     Sand, gm       Sensitivity to labletion:     Minimum Defonating Charge, gm       Mercury Fulminate     Lead Axide       Tetryi     Plate Deat Test:       Plate Deat Test:     Method       Condition     Carifinad       0.00     Density, gm/cc       None     Detenstion flats:       Condition     C'arge Diameter, in.

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#### 1,3,5-Triamino-2,4,6-Trinitrobensene (DATHB)

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#### Preparation:

Absolute alcohol (200 milliliters) was saturated with ammonia and then 22.5 gm (0.028 mol) of 1,3,5-tribromo-2,4,6-trimitrobenseme, prepared according to Hill (MAVORD Report Ho. 3709, 2 February 1953), was added. The flask was stoppered and allowed to stand at room temperature for a day. additional ammonia was bubbled into the mixture, which was then heated ander reflux for thirty minutes, filtered hot, and the insoluble product collected on a Bucher funnel. The product was washed with water, alcohol, and dried. The 4.7 gm of material recovered was recrystallised from nitrobenseme.

A disadvantage of the above method was that it could not be used for the preparation of large quantities of TATME. Since it did not seem fearible to develop a net wethod of preparation, an investigation was made of the reported amination reactions (see <u>Origin</u> below). An attarpt was made (Ref f) to find a modification which would produce high yields of a pure product. The process which evolved from this study may be summarized as follows (Ref 2): 1,3,5trichlorobensene was nitrated "in one step" to 1,3,5-trichloro-2,4,6-trinitrobensene in 85% yield. The crude nitration product was aminated in benzene with amonia gas to TATME, in yields of at least 95%.

#### Origin:

TATHE was prepared for the first time in 1888 by C. L. Jackson and J. F. Wing, who f and the compound insoluble in alcohol, ether, chloroform, benzene, and g'acial acetic acid; and soluble in nitrobenzene and aniline (Amer Chem Journal 10, 282 (1668)). B. Flurscheim and E. L. Holmes prepared TATHE from benzene free pentanitroaniline by gradually adding it to 10% equeous sumonia (J Chem Soc, Pt 2, 3045 (1928)). After boiling, an orange-yellow powder me)\*ing above 300°C was obtained. This product corresponded to that described by Jackson and wing. These authors, as well as Palmer (Amer Chem Journal 14, 378 (1892.), attempted to reduce 24THE to hem-sumobenzene. Either decomposition occurred or a hydrochlorid's of penta-sumobenzene was formed. Plursch. 4 and Holmes succeeded in reducing TATHE with paraglepirasine by heating them together up to 200°C (J Chem Soc, Pt 1,334 (1929)) (Brill 12, 301 and EIJ, 147).

#### References:77

(a) F. Taylor, Jr., Synthesis of May High Explosives II, Derivatives of 1,3,5-Tribromo-2,4,6-Trinitrobenzeme, MAVORD Report Ho. 4405, 1 November 1956.

(b) L. D. Hampton, <u>Small Scale Detonction Velocity Measurements from May 1951 to May 1954</u>, MAYORD Report No. 3731, June 1954.

(c) E. M. Pisher and E. A. Christian, <u>Explosion Effects Data Theets</u>, NAVORD Report No. 2986, 14 June 1955.

<sup>77</sup>See footnote 1, page 10.

Compeutites:	Melecular Weight: (C68128208, 240
94 с 29.9 H <sub>2</sub> с н 5.4 н - <sup>0</sup>	Oxygen Belance:           CO2 %         -89           CO %         -27
W 11.7	Density: gm/cc 20°C 1.33 25°C 1.32
o 53.0 <sup>₩</sup> 2 <sup>C</sup> >0	Moliling Point: *C
C/H Ratio 0.17; H2CC CH20102	Freezing Point: "C
Impast Smalth-try, 3 Kg Wt: Bureau of Mines Apparatus, cm 100-	Bolling Point: *C
Bureau of Mines Apparatus, cm 100 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 43 Sample Wt, mg	Refrective Index, nº 1.454 nº 1.454
Fristion Pendulum Test:           Studi Shoe         Unaffected           Fiber Shoe         Unaffected	Vecuum Stability Test: cc/40 Hrs, at 90°C
Riffo Bullet Impact Test: Trials	100°C 0.45 120°C 8 hours 0.8
% Explosions Partials	135°C 150°C
Burned	200 Gram Bomb Sand Test: Sand, gm 14.7
Explexion Temperature: *C Seconds, 0.1 (no cap used)	Sensitivity to Initiation: Minimum Detonating Charge, gm
1 5 223	Mercury Fulminate
10	Leod Azide Tetryi
15	Bellinic Morter, % TNT:
20	Treuzi Test, % TNT:
75°C International Heat Test: % Loss in 48 Hrs	Plate Dest Test:
100°C Heat Test:	Method Condition
% Loss, 1st 48 Hrs 1.8	Confined
% Loss, 2nd 48 Hrs 1.6	Density, gm/cc
Explosion in 100 Hrs None	Brisance, % TNT
Flemmubility Index:	Confinement Shelby ster
Hygroscopicity: %	Condition Liguid Charge Diameter, in. 1.25
Ve/unility: 60°C, mg/cm <sup>2</sup> /hr 40	Density, gm/cc 1.33

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#### AMCP 706-177

### Triethylene Glycol Dinitrate (TEGN) Liquid

	and This of cor	Managere (2000) Maria	(
Progmantation Test:	n.	Shaped Charge Effectiveness, TNT	'= 100:
90 mm HE, M71 Projectile, Let W	C-91:	Gloss Cones S	reel Cones
Density, gm/cc		Hole Volume	
Charge Wt, Ib		Hole Depth	
Total No. of Fragmants:		Celer:	
For TNT			
For Subject HE		Principal Uscs: Ingredient of	rocket and double
3 inch HE, M42A1 Projectile, Let I	(C-5;	base propellar	
Density, gm/cc			
Charge Wt, Ib			
Total No. of Fragments:	1	Method of Loading:	
For TNT			
For Subject HE			
		Loading Density: gm/cc	
Fregment Velecity: ft/sec			
At 9 ft At 25¼ ft		<b>*</b>	
		Storoge:	
Density, gm/cc		Method	Liquid
Sisst (Relative to TNT):		Hazard Class (Quantity-Distance	••
<b>A 2</b>		Compatibility Group	
Air: Pack Pressure		Companionity Group	
impulse		Exudation	
Energy			
		Solubility in Water,	
Air, Confined:		gm/100 gm, at:	
Impulse		25 <sup>0</sup> C 60°C	0.55 0.68
Under Weter: Peck Pressure		Solubility, gm/100 gm,	0.00
Impulse		at 25°C, in:	_
Energy		Ether Alcohol	•
C		2:1 Ether:Alcohol	•
Underground:		Acetone	<b>•</b>
Peak Pressure		Viscosity, centipoises:	
Impulse		Temp, 20°C	13.2
Energy		Hydrolysis, % Acid:	
Heat of:	·	10 days at 22°C 5 days at 60°C	0.032 0.029
Combustion, cal/gm	3428	Vapor Pressure:	
Explosion, cal/gm Gas Volume, cc/gm	357 851		m Mercury
010 (01110) 0(/Bm	<i>∽</i> / <b>▲</b>	25	< 0.001

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#### Triethylene Glycol Dinitrate (TBGN) Liquid

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#### Origin:

Lourence prepared triethylene glycol in 1863 by realing glycol with ethylene bromide in a sealed tube at 115°-120°C (Ann (3) 67, 275). Later in the same year Wurtz prepared triethylene glycol by heating ethylene oxide with glyce" at  $100^{\circ}$ C. By action of nitric acid triethylene glycol was oxidized to (H<sub>2</sub>OOC CH<sub>2</sub>·O-CH<sub>2</sub>)<sub>2</sub> (ann (3) 69, 331, 351).

The Germans and Italians were the first to prepare and use TEGN during World War II as an ingredient of rocket and propellant powders. The commercial production of TEGN in quantity is still difficult and its use as plasticizer for nitrocellulose is being replaced by other liquid nitrates.

#### Preparation:

Tristhylens glycol is purified by fractional distillation under vacuum in an 18-inch Vigeaux fractioning column. The assembly as a whole is equivalent to 4.5 theoretical plates. The distillation is conducted using a 5 to 1 reflux ratio, at a pot temperature of approximately 180°C, and a take-off temperature of approximately 120°C.

The purified trigthylene glycol (TEG) is nitrated by carefully stirring it into 2.5 parts of 65/30/5 nitric acid/sulphuric acid/water maintained at  $0 \pm 5^{\circ}$ C. The rate of cooling is sufficient that 300 gm of TEO can be added within 40 minutes. The mixture is stirred and held at  $0 \pm 5^{\circ}$ C, for 30 additional minutes. It is then drowned by pouring onto a large quantity of ace and extracted three times with other. The combined extract is water-washed to a pH of about 4, shaken with an excess of sodium bicarbonate solution, and further washed with 15 modum bicarbonate solution until the washings are colorless. The othersal solution is water-washed until it has the same pH value as distilled water. It is careful separated from excess water, treated with chemically pure calcium chloride to remove dissolved water, and filtered. The ether is removed by bubbling with dry air until a minimize mate of loss in weight is attained. The yield is 1.34 gm per gm TEG (84% of theoretical) and the nitrogen content of different batches range from 11.60 to 11.69% by the nitrometer method (calculated 11.67%).

### References; 78

(c) See the following Picatinny Arsenal Technical Reports on TEGN:

<u>3</u>	٤	<u>6</u>	I	<u>8</u>
1953 2193	1745	1786 <b>20</b> 56	1767 1817	1638

78See footnote 1, page 10.

### AMCP 706-177

Trimonite

Composition:	Melecular Weight:	217	
·	Oxygen Balence:		7
Pierie Acià 88 - 90	CO. %	-62	
Mononitronaphthalene 12 10	CO %	-14	
initial a clight meteric. Tr. TA	Density: gm/cc Cast	1.60	7
	Molting Point: *C	90	-
C/H Ratio	Freezing Point: "C	~ · · ·	
Import Sansitivity, 2 Kg Wt:	Solding Point: 'C Explodes	300	
Burecu of Mines Apparatus, cm 60 Sample Wt 20 mg	Refrective index, no		-i
Picotinny Arsenal Apparatus, in. 10	-		
Sample Wt, ing	n <sub>a</sub> o		
	nso		
Friction Persitation Test:	Vocuum Stebility Test:	<u></u>	-
Steel and	cc/40 Hrs, at		
Fiber Shoe	90°C		1
	100°C		
Rifle Bullet Impact Test: Trials	120°C	0.9	
%	135°C	0.9	
Explosions 0	150°C		
Portials 0	130 C		
Burned 0	200 Gram Bamb Sand Test:		
Unoffected 100	Sand, gm	44.2	1/-
Explosion Temperature: *C	Sensitivity to Initiation:		
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gm		
1	Marcury Fulminate		
5 Decomposes 315	Leod Azide	0.20	
10	Tetryi	0.04	
15			-
20	Bellietic Morter, % TNT:	· · ·	4
75°C International Heat Test:	Treusi Test, % TNT:		
% Loss in 48 Hrs	Plate Dant Test: Method		-
100°C Heat Test:	Condition		
% Loss, 1st 48 Hrs	Confined		
% Loss, 2nd 48 Hrs	Density, gm/cc		
Explosion in 100 Hrs	Brisonce, % TNT		j
	Detenction Rate:	····	1
Flammability Index:	Confinement	None	
	Condition	Cagt	
Hygrescopicity: %	Charge Diameter, in.	1.0	
	Density, gm/cc	1.60	
Velatility:	Rate, meters/second		
		7020	

### Trimonite

AMCP 706-177

Fregmontation Test:	Shaped Cherze Effectiveness, TNT = 100:	
90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge W(, Ib	Gloss Cones Steel Cones Hole Volume Hole Depth	
Total No. of Fragmants: For TNT	Color:	
For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib	Principal Uses: TNT substitute in projecti and bombs	lles
Toral No. of Fragments: For TNT For Subject 14E	Mothod of Loading: Cast	t
For Subject IIE Fregment Velocity: ft/sec At 9 ft	Looding Density: gm/cc 1.60	)
At 25½ ft Density, gm/cc	Storoge: Method Dry	
Blast (Relative to TNT):	Hazard Class (Quantity-Distance) Clas	sa 9
Air: Peok Pressure Impulse Energy	Compatibility Group Grou Exudation Exudes at 5	ир I 50 <sup>0</sup> С
Air, Cenfined: Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse Energy	Preparation: Picric acid and alpha-mononitronsphti are melted together in an aluminum or ti jacketed melt kettle equipped with a sti Although picric acid alone requires a hi perature for its melt loading (120°C), t mixture forms a sutectic melting at 49°C must be taken to prevent the formation of gerous metallic picrates. Trimonits is interest as an emergency substitute for	in steam Irrer. Igh tem- the C. Care of dan- of

AMCP 706-177

#### Trimonite

#### Origin:

- ALA

Trimonite, a castable mixture of picric acid/mononitronaphthalene was developed by the British during World War II as an improvement over tridite which is a mixture of 80/20 picric acid/dinitrophenol. Both mixtures are suitable for melt-loading below  $100^{\circ}C$  and therefore represent an improvement over melt-loading picric acid alone (melting point  $122^{\circ}C$ ). However, tridite is slightly inferior to picric acid as an explosive and dinitrophenol is objection-able because of its toxicity. Trimonite is also slightly inferior to picric acid and TNT as an explosive. Because of the low eutectic temperature of the picric acid-mononitromaphthalene mixture ( $49^{\circ}C$ ), Tridite exudes when stored at elevated temperatures. It does not possess the disadvantages of picric acid (corrosive action on metals, ease of decomposition, etc.) and is a comparatively interpensive substitute for TNT.

### References: 79

(a) See the following Picatinny Arsenal Technical Reports on Trimonite:

2	2	<u>6</u>	8
1352	1325	926 976	1098 1838

<sup>79</sup>See footnote 1, page 10.

Composition: %	Meleraler Weight: (C6H6N6C	) <sub>14</sub> )	<b>3</b> 66
с 18.6 н 1.6	Oxygen Belence: CO <sub>2</sub> % CO %		-4.2 20.8
$x = 21.8$ $(-CH_2C(NO_2)_3)$ C = 0	Density: gm/LC For	m I	1.78
0 58.0 \	Melting Point: *C		93
C/H Rotio 0.202 CH2CH2C(NO2)3	Freezing Point: "C		
Impact Sensitivity, 2 Kg Wt: Bureou of Mines Apparatus, cm	Boiling Point: "C		
Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg 50% point, cm (a) 20	Refrective Index, no Fo Crystal Axis	orm I β T	(e) 1.518 1.527 1.546
Friction Pondulum Test: Steel Shoe Fiber Shoe	Vacuum Stability Test: cc/40 Hrs, at 90°C		
Rifle Bullet Impact Test: Trials % Explasions	- 100°C 48 hrs 120 C 135°C		0.60
Portiols Burned Unoffected	150°C 200 Grem Bomb Send Test:		
Explesion Temperature: °C Seconds, 0.1 (no cap used) 1 550% point (Alhot bar) (a) 225 10	Sand, gm Sensitivity to Initiation: Minimum Detonating Charge Mercury Fulminate Lead Azide Tetryl	;, gm	
15 20	Baliletic Morter, % TNT: (1	b)	136
	. Treuzi Test, % TNT:		
<b>75°C international Heat Test:</b> % Loss in 48 Hrs	Plate Dent Test: Method		
100°C Heat Tust:	Condition		
	Confined		
% Loss, 1st 48 Hrs	Density, gm/cc		
% Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs			
	Brisonce, % TNT		
% Loss, 2nd 48 Hrs Explosion in 100 Hrs	Brisance, % TNT Detenation Rate: Confinement		
% Loss, 2nd 48 Hrs	Brisonce, % TNT Detenation Rate: Confinement Condition Charge Diameter, in.		1.76

2,2,2-Trinitroethyl-4,4,4-Trinitrovityrete (TNETB)

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### AMCP 706-177

#### 2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrete (TNETB)

		· · · · · · · · · · · · · · · · · · ·	
Beestor Sensitivity Test: Condition		Decomposition Equation: Oxygen, atoms/sec	4.4 x 10 <sup>21</sup>
Tetryl, gm		(Z/sec)	
Wax, in. for 50% Detonation		Heat, kilocalorie/mole (AH, kcal/mol)	43.4
Wax, gm		Temperature Range, °C	
Density, gm/cc		Phase	Liquid
Heat of:		Armer Plate Impect Test:	
Combustion, col/gm	1685		
Explosion, cal/gm		60 mm Morter Projectile:	
Gas Volume, cc/gm		50 <sup>e</sup> Inert, Velocity, ft/sec	
Formation, cal/gm	307	Aluminum Fineness	
Fusion, col/gm Sublimation, cal/gm (e.t)	804	SOO-Ib General Purpose Bombs:	
ipecific "iest: cal/gm/*C			
		Plate Thickness, inches	•
		114	
		114	
		134	
urning Rate:			
cni/sec			
		Bomb Drop Test:	
Thermal Conductivity:		T7, 2000-Ib Semi-Armer-Piercing	Romh ys Concrets
col/sec/cm/*C			
coefficient of Expension:		Max Safe Drop, ft	
Linear, %/°C		500-lb General Purpose Bomb vs	Concrete:
Volume, %/*C		Height, ft	
		Triols	
Herdness, Mohs' Scele:		Unaffected	
		Low Order	
(oung's Modulus:		High Order	
E', dynes/cm <sup>*</sup>		-	
E, Ib/inch <sup>2</sup>		1000-Ib General Purpose Bomb vi	Concrete:
Density, gm/cc			
ampagelie despeth in /insh2			
empressive žtrength: Ib/inch <sup>2</sup>		Trials	
		Unaffected	
Vapor Pressure:	(e)	Low Order	
*C mm Mercury		High Order	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$			
75 1.3 x 10			
75 1.3 x 10 L			

#### 2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrate (TNETB)

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1000

「「いたい」

Fragmentation Test:	Shaped Charge Effectiveness, TNT = 100:
90 mm HE, M73 Projectile, Lot %/C-97:	Glass Cones Steel Cones
Density, gm/cc	Hole Volume
Charge Wt, Ib	Hole Depth
Total No. of Fragments:	Celer: Coloriesa
For TNT	Coloriess
For Subject HE	Sincipal Uses:
3 inch HE, M42A1 Projectile, Lc? KC-5:	
Density, g-n/cc	
Charge W7, ib	
Total No. of Fragments:	Method of Looding:
For TNT	
For Subject HE	
	Looding Density: gm/cc Form I 1.783
Fregment Velocity: fr/sec	Form II 1.677 Liquid, 99°C. 1.551
At 9 ft At 25½ ft	Storege:
Density, gm/cc	
ounary, yn, cc	Method Wet
Bless (Relative to H-6;: Sphere Cylinder (h)	Hazara Class (Quantity-Distance)
Air: 1-1b Charge: EW# EV# EW# EV# Peak Pressure 0.91 0.84 0.81 0.75	Compatibility Group
Impulse 0.73 0.67 0.74 0.69	Exudation
Energy	
Ellergy	
Air, Confined:	Bruceton Safety Test Results: (g)
impulse	Mean and standard deviation of lengths o
Under Weter:	0.300 diameter cylinder across which initia
Under weter: Peak Pressure	tion is possible for 50% certainty:
Impulse	INT 0.391 ± 0.640
Energy	RDX Comp B 0.361 7 0.042 TIETE 0.920 7 0.059
	IIIETB 0.920 <u>∓</u> 0.059
Underground: Peak Pressure	Absolute Viscosity, poises: (e)
Impulse	Тетр, 98.9 <sup>°</sup> с 0.173 106.5 <sup>°</sup> С 0.138
Energy M, equivalent weight of H-6 fex a unit weight f test mixture for equal performance at the ame test distance; M, equivalent volume of -6 for a unit volume of test mixture for equal	
erformance at the same test distance.	

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#### 2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrate (THETE)

	Solubility
	Insoluble
ane	Insoluble
n tetrachloride	Insoluble
01	5 gm/100 gm solvent
of orre	5 gm/100 gm solvest
Be .	10 gm/100 gm solvent
methane	Very soluble
al Leatic acid	Very soluble
acetate	Very soluble
	bllowing Compounds: (a)
al Lostic acid	Very soluble Very soluble

rystallographic Data:	(a)	
THE (trinitrobenzene) Compound A (CLHCHLO, formed by condensation of 1,1-dinitroethane) Trinitroethyl trinitrobenzoate (27%)	65 77 80.5 (£)	• • •
INT BINES (bis(trinitroethyl) succinate) BINEN (bis(trinitroethyl) nitramine)	57 80+ 68.5	

#### Crystallographic Data:

Three polymorphic crystalline forms have been observed. Low temperature Form I goes through a solid-solid transition at  $89^{\circ}$ C giving Form II. Form II has a melting poi... of  $92.5^{\circ}$  to  $93^{\circ}$ C. On cooling, Form II does not transform reversibly to Form I when  $89^{\circ}$ C is reached. However, Form II will transform to Form I at room temperature, usually taking a few hours to do so. Form III was observed, which appeared to be stable over a vary narrow temperature range on the order of  $0.2^{\circ}$  to  $0.3^{\circ}$ C near  $92.5^{\circ}$ C.

#### Preparation:

(d)

		•••	•
(110 <sub>2</sub> ) <sub>3</sub> CCH <sub>2</sub> CH <sub>2</sub> COC1 +	(NO2)3 CH20H	H2504	
trinitrobutyryl chloride t	rinitroethanol	sulfuric acid	
$(\mathbb{N}_2)_3$ CCH <sub>2</sub> CH <sub>2</sub> COOCH <sub>2</sub> C $(\mathbb{N}_2)_3$	+ HCL	· · · · · · · · · · · · · · · · · · ·	]
2,2,2-trinitroethyl-4,4,4-tri butyrate	nitro- hydro ac	chloric id	

Laboratory experiments indicate that the present slow step involving overnight treatment of 4,4,4-trinitrobutyryl chloride with 2,2,2-trinitroethanol and aluminum chloride can be replaced by a fast and simple esterification in sulfuric acid. Using 100% sulfuric acid or fortified H<sub>2</sub>SO<sub>4</sub>, the ester can be prepared in yields of 95% to 95% in 24 hours at 25°C, in 5 hours at 50°C, or in 3 hours at 65°C. Above 65°C the reaction time is less, but the yield falls off and a less pure product is obtained. The crude white crystalline product on recrys-tallization from dilute methanol gives a material melting at 92° to 93°C.

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#### 2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrate (THETE)

AMCP 706-177

#### Origin:

WWW.SURVIVALEBOOKS.COM

#### (•)

THETE belongs to a now class of explosives characterized by trinitromethyl groups,  $-C(MD_p)_2$ . The chemistry of this class of compounds was studied in Germany by Drs. Schenck and Schumelschnidt, who discovered in 1942-1945 at trinitromethane or nitroform,  $HC(MD_p)_2$ , was the source of new explosive derivatives. Dr. Schuck prepared the stable solid alcohol, 2,2,2-trinitroethanol, from nitroform and formaldehyde. Dr. Schumelschnidt reacted nitroform with unsaturated organic compounds, such as acrylic acid, and predicted in 1943 that the ester of 4,4,4-trinitroethanol with trinitroethanol would be an interesting explosive.

In 1947 the U.S. Havy began a program to explore these comports. The initial task of investigating the chemistry of trinitroethanol was undertaken by the Hercules Powder Company (Havy Contract HOrd-9925). The U.S. Rubber Company studied the chemistry of nitroform (Havy Contract HOrd-10;129). After preparation of the first laboratory samples of THETE, considerable interest was aroused. In early 1950 the Haugatuck Chemical Division of U.S. Rubber Company was assigned to prepare 100 pounds of THETE. The Bureau of Ordnancy in July 1953 raised the production to 800 pounds with the assistance of the Harcules Powder Company in anguling the production at Brugatuck (Havy Contract HOrd-11,280). THETE is a high oxygen contex explosive.

#### Beferences: 80

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(a) J. M. Rosen, <u>Properties of Trinitroethyl Trinitrobutyrate THETB</u>, MAVORD Report No. 1758, 17 December 1950.

(b) Bureau of Mines Report No. 3107, Part IX, Ballistic Mortar Tests on Trinitrosthyl Trinitrobutyrate, 5 April 1950.

(c) L. D. Hampton and G. Svadeba, <u>Evaluation of 2,2,2-Trin troethyl-4,4,4-Trinitrobu', te</u> ac a Constituent of Castable Explosives, HAVORD Report No. 261, 30 September 1952.

(d) U.S. Bubber Company Quarterly Progress Report No. 23, <u>Prothesis of New Propellants</u> and Explosives, New Contracts Word-10-129 and -12,663, 19 August 1 /53.

(e) M. E. Hill, O. H. Johnson, J. M. Rosen, D. V. Sickman and F. Taylor, Jr., <u>Preparation</u> and Properties of THETE, a New Castable High Explosive, MAVORD Report Ko. 3685, 27 January 1955.

(1) N. E. Hill, Synthesis of New High Explosives, NAVORD Report No. 2965 1 April 1953.

(g) Jacob Savitt, <u>A Sensitivity Test for Castable Liquid Explosives, Including Results</u> for Some New Materials, HAVORD Report No. 2997, 22 October 1953.

(h) R. W. Gipson, <u>Sensitivity of Explosives, IX:</u> Selected Physico-Chemical Data of <u>Nen</u> Pure High Explosives, MAVORD Report No. 6130, 18 June 1958.

80See footnote 1, page 10.

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### Trinitro Triazidobenzene

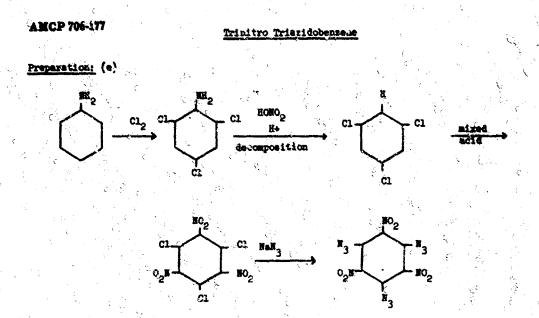
Comprolition:	Melecular Weight: - (C6 <sup>0</sup> 6 <sup>N</sup> 12)	336
<b>1</b> 96	Gaygen Relevice:	
	CO2 %	-29
	CO %	0.0
	Beneity: gm/cc Crystel	1.81
	Meiting Point: "C Decomposes	131
C/H Rotio	Freezing Polet: "C	<u> </u>
Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm (a) \$25	'Boiling Point: "C	
Sample Wt 20 mg	Refrective Index. no	
Picationy Arsenal Apparatus, in.	nB	
Sample Wt, mg	n <sub>m</sub>	
Fristian Pandulum Test:	Vocuuse Stability Tast:	
Steel Shoe	cc/40 Hrs, at	
Fiber Shoe	90°C	
Rifle Buliet Impact Tert: Trials		
	120°C	
% Explosions	135°C	
Portiols	150°C	
Burned	200 Gruna Bottala Sand Test:	
Unoffected	Sand, gm	
Explosion Temperature: "C (a)	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used)	Minimum Detonating Charge, gm	
5 150	Mercury Fulminate	
	Lead Azide	
10	Tetryl	
15 .	Sellistic Martar, % TNT:	
20	Trouzi Toit, % PFIN:	90
75°C International Heat Test:	Plate Dent Test:	
% Loss in 48 Hrs	Method	
	Condition	
100°C Heat Test:	Confined	
% Loss, 1st 48 Hrs	Density, gm/cc	
% Loss, 2nd 48 Hrs	Brisance, % TNT	
Explosion in 100 Hrs		
file and a thirty is a data	- Detenction Rate:	
Renmebility Index:	Confinement	
Hygrescepicity: % 30°C, 90% RP 0.00	Condition	
Hygreecepicity: % 30°C, 90% RP 0.00	Charge Diameter, in.	
Madaatila	Density, gm/cc	
Veletility:	Rate, meters/second	

. .

#### Trinitro Triazidobenzena

AMCP 706-177

egmonistion Test:	Shaped Charge Effectivenese, TM	
90 mm HL, M71 Projectile, Lat WC-91:	Glass Cones 5	teel Cones
Density, gm/cc	Hole Volume	
Charge Wt, Ib	Hole Depth	
Total No. of Frugments:	Caler: Gree	nish-yellow
For TNT	E g	• • • • •
For Subject HE	Principel Uses: (c) Ingredi	ent of primer mix
3 inch NE, M42A1 Projectile, Let KC-5:		
Dansity, gm/cr.		
Charge Wt, Ib		
Telui No. of Fragments:	Method of Looding:	Fressed
For TNT	Dead presses at about 4	2,000 psi
For Subject HE		
· · ·	Leading D milly: gm/cc	
nent Velocity: ft/sec	At 42,000 psi	1.75
h i i i i i i i i i i i i i i i i i i i	Storego:	
5% ft		
, gm/cc	Method	
Relative to TNT):	Hazard Class (Quantity-Distan	:e)
lir.	Compatibility Group	ر د ۱۰
Peak Pressure	P. dealers	Mana
Imputse	Exudation	None
Energy		
1. A. B	Qualitative Solubilities at Room l'emperature:	· · ·
.ir, Cenfined: Impulse		C-1.5414
	Solvent	Solubility
Inder Water:	Acetone Chloroform	Readily soluble Moderately solubl
Peok Pressure	Alcohol	Sparingly soluble
impulse -	Water	Insoluble
Energy	Compatibility with Metals:	
ndorground:	Wet: Does not attack i	ron, steel, copper
Peak Pressure	or or ss.	
Impulse	Heat of:	
Energy	Combustion, cal/gm	(a) 2554
	Burning Rate:	(b)



Aniline is chlorineted to form trichlon camiline. The amino group is eliminated by the Aniline is chlorineted to fore trichlorosniline. The amino group is eliminated by the disco reaction. The resulting (yo-trichlorobensene is aitrated. This nitwation is carried out by dissolving the material in warm 325 clean, solding strong mitric acid, and heating to 140°-150°C until no trimitro trichlorobensone (melting bont 187°C) precipitates (Ref f). The chlorine groups are then replaced by azo groups. This is accomplished by adding at ace-tone solution of the trimitro trichlorobensene, or better, and possible by adding at ace-tone solution of the trimitro trichlorobensene, or better, and possible by adding at ace-tone solution of the trimitro trichlorobensene, or better, and possible by adding at ace-tone solution of the trimitro trichlorobensene, or better, and possible trimitro triaxido-bensene is collected on a filter, washed with alcohol, water and dried. It may be purified by dissolving in chlorotorm, allowing the solution to cool, and collecting the greenish yellow crystals (melting point 131°C with decorposition).

#### Origin:

This initiating explosive was first prepared in 1923 by Turek who also perfected its ganufacture.

### References:81

(a) S. Helf, Tects of Explosive Compounds Submitted by Arthur D. Little, Inc., PATR 1750, 24 October 1949.

(b) A. r. Belyaeva and A. E. Belyaeva CR a.s. USSR 52, 503-505 (1946) Chemical Abstracts 41, 4310.

A. E. Belyaeva and A. F. Belyaeva, Doklady Akad Mauk. USSR 56, 491-494 (1947).

(c) French Patent 893,941, 14 November 1944 (Chemical Abstracts 47, 8374).

(d) A. D. Yoffe, "Thermal Decomposition and Explosion of Azides," <u>Proc. Roy Soc</u> A208, 188-199 (1951).

(e) T. L. Davis, <u>The Chemistry of Fowder and Explosives</u>, John Wiley and Sons, Inc., New York (1943), p. 436.
(f) O. Turek, Chim et Ind <u>26</u>, 781 (1931); German Patent 498,050; British Patent 298,981.

<sup>81</sup>See footnate 1, page 10.

### Contraction of the second

### Tripentaerythritol Octanitrate (TPEON)

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Compatibles	Melecular Weight: (C15H24N8026)	732
Č 24.6	Oxygen Belerce:	
	CO, %	-2.2
<b>3 3 3 5 3 6 6 6 6 6 6 6 6 6 6</b>	© %	-2.2
Carono 2 Carono 2 Carono 5	Densky: gm/cc Crystal	1.58
	Melting Point: *C 85	to 84
C/H Rand Qurs	Freezing Point: *C	
Bureau of Mines Apparatus, cm	Boiling Point: *C	
Sample Wt 29 mg	Refrective Index, nm	
Picatinny Arsenal Apparatus, in. 9	ng	
Sample Wr, ing 24		
	n <u>2</u>	
Friction Pondulum Test:	Yacuum Stability Test:	<u>.</u> <u>.</u>
	ected cc/40 Hrs, ot	
Fiber Shoe Unati	ected 90°C	
Rille Bullet Import Test: Trials	100°C Pure	2.45
	120°C Specially purified	1.94
% Explosions	135°C	
Patticis	150°C	
Burned	200 Grem Bemb Send Test:	
Unoffected	Sond, gm	58.9
Explosion Temperature: *C	Sensitivity to Initiation:	
Seconds, 0.1 (nc cap used)	Minimum Detonating Charge, gm	
1	Mercury Fulminate	
5 225	Lead Azide	0.30
· 10	Tetryl	****
15		
20	Bellistic Mortur, % TNT:	
75*C International Heat Test:	Trouzi Toot, % TNT:	
% Loss in 48 Hrs	Plate Dent Test:	
	Method	
100°C Heat Test:	Condition	
% Loss, 1st 48 Hrs 1.15	Confined	
% Loss, 2nd 48 Hrs 0.75	Density, gm/cc	C.
Explosion in 100 Hrs None	Brisance, % TNT	
	Detenction Rate:	
Finanability Index:	Confinement	None
	Condition	Pressed
Hygreecepicity: %	Charge Diameter, in.	0.5
Voletility:	Density, gm/cc	1.56
v exercisy:	Rate, meters/second	7650

### AMCP 706-177

### Tripentaerythritol Octanitrate (TPEON)

AMCP 706-177	Tripentserythrito)	l Octanitrate (TPEON)		
Beester Sanshivity Test: Candition Tetryl, gm Wax, in: for 50% Detonation Wax, gm Density, gm/cc Heat ef: Cambustion, col/gm Explasion, col/gm Formation, col/gm	2632 1085 762	Decomposition Equation. Oxygen, ctoms/sec (Z/sec) Heat, kilocolorie/mole (AH, kcal/mol) Temperature Range, "C Phase Armor Plate Impact Test: 60 mm Marter Projectile: 50% Inert, Velocity, fr/sec Aluminum Fingness	23.1 215 to 250 Liquid	
fusion, ce:/gm	······································	500-Ib Ganeral Purpase Bounbs:		
Specific Mest: col/gm/°C Specific Impulse: lb-sec/lb (calculated)	240	Plate Thickness, inches 1 1¾ 1½		
Burning Rate: cm/sec		Bomb Drop Toot:		
Thermal Conductivity: col/sec/cm/°C		T7, 2000-16 Semi-Armer-Piercin	g Bamb vs Concrete:	C
Coefficient of Expension: Linear, %/*C		Max Safe Drop, ft <b>500-15 Gameral Purpose Bomb v</b>	s Concrute:	
Volume, %/*C Herdness, Mahs' Scele:		Height, ft Trials Unoffected		
Young's Madulus: E', dynes/cm <sup>2</sup> E, lb/inch <sup>2</sup>		Low Order High Order 1990-Ib General Purpose Bemb	rs Cenerato:	
Density, gm/cc Compressive Strongth: Ib/inch <sup>2</sup>		Height, ft Trials Unaffected		
Veper Pressure: *C mm Mercu	Ŋ	Low Order High Order		

### Tripentaerythritol Octanitrate (TPBON)

AMCP 706-177

Fragmentation Test	Shaped Charge	Effectivoneen	, TNT = 1	<b>99:</b>	
90 mm HE, M71 Projectile, Let WC-91:		Glass Cones	Steel (	Cones	
Density, gm/cc	Hole Volume				
Charge Wt, Ib	Hole Depth				
Total No. of Progmants:	Celen			Whit	
For TNT	<b>Cont</b>			WELL	
For Subject HE	Balanda al III an				
3 inch HE, M42A1 Projectile, Lat KC-5:	Principal Uses:			itroceliulo	
Density, gm/cc					
Charge Wt, Ib					
Total No. of Fragmants:	Method of Lood	lee:	Cas	t or presse	a
For TNT					-
For Subject HE					
	Looding Density				-
Fregment Velecity: ft/sec	Pressed at	00,000 ps1		1.56	>
At 9 ft At 25½ ft	Storege:				
Density, gm/cc	Method			Dry	. •
Blast (Relative to TNT):	Hozard Class	(Quantity-Di	istonce)		
Air:	Compatibility	Gloup		•	
Peak Pressure					
Impulse	Exudation			None	
Energy					
Air, Confined:	Hygroscopici	ty, Gein o	r Loss i	n Wt., <b>\$:</b>	
Impulse	Time, Hrs	S RH	at <u>30°</u> C		
Under Water: Peak Pressure		40	70	_90	
Impulse	24	-0.008	+0.01	+0.0	
_ •	48	-0.02	-0.01	+0.02	
Energy		-0.04	-0.03	-0.02	
Underground: Peak Pressure		-0.04 -0.004	-0.02 -0.01	+0.03	
	Solubility:				
Impuls. Energy					
र- न्या <b>भ्र</b> म	Solven	<u>t</u>	Solub	ility	
	Weter		Insolu		
	Alcoho		Solubl		
	Chloro Aceton		Solubl Very s		
		e, hot e, hot	Very s Very s	ATTANTA	

#### AMCP 706-177

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#### Tripentaerythritol Octanitrate (TPEON)

### Compatibility With Other High Explosives:

### 100°C Vasuum Stability Test:

	NIN	PEIN	RDX	TPEON
ml gas/40 hrs, 5 gm sample	0.14	2.15	0.39	2.45
ml gas/40 hrs, 5 gm sample of 50/50, TPEON/HE	1.89	1.71	2.32	_

Dipentacrythritol Hexanitrate (DPEHN)-TPEON Fusions:

\$ TPRON	% DPERN	Solidification Time, Days	MP, C
100	0	-	83
<del>9</del> 5	5	3	68
90	10	3	69
80	20	5	73
50	50	30	60 (Butectic)
20	80	5	63
10	90	3	69
0	100	-	73

#### Preparation:

(a)

Twenty graves (0.054 mol) of nitration grade tripentacrythritol (TFE) (99%) minimum purity) were slowly added, with stirring, to 160 gm (2.55 mol) of 99% nitric acid at a temperature of -25° to 0°C. On equivalent weight basis, this quantity of 99% nitric acid corresponds to an excess of 6.3 times the TFE used. After addition of the TFE, thereaction mixture was stirred for about one hour at 0° to 5°C and poured into eight times its volume of cracked ice. The product, when allowed to stand overnight, was crushed under water; filtered with suction; and washed copicually with water. It was then treated twice with about 5 times its weight of a 1% ammonium carbonate solution, stirred for several hours, filtered and washed successively with 50 cc rach of ethanol and ether. The material dried in air weighed 37.8 gm or 96% of theory based on TFE. It had a melting range of 71° to 74°C. Crystallization of the crude TFEON from chloroform was found to be the most suitable method of obtaining pure TFEON.

#### Origin:

TPEON prepared by the reaction of tripentaerythritol and 99% nitric acid at  $0^{\circ}$  to  $10^{\circ}$ C was reported by Wyler in 1945 (J. A. Wyler to Trojan Powder Company: U.S. Patent 2,389, 228, 20 November 1945).

#### Tripentaerythritol Octanitrate (TPBON)

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### References: 82

(s) J. J. LaMonte, H. J. Jackson, S. Livingston, L. B. Silberman and N. N. Jones, <u>The</u> <u>Preparation and Explosive Properties of Tripentmerythritol Octanitrate</u>, PATR No. 2490, 1958.

(b) K. Manba, J. Yamashita and S. Tanaka, "Pentaerythritol Tetranitrate," J Ind Explosives Sec (Japan) 15, 282-9 (1954); CA 49, 11283 (1955).

(c) S. D. Brewer and H. Henkin, The Stability of PETH and Pentolite, OSRD Report No. 1414.

(d) E. Berlow, R. H. Barth and J. E. Snow, <u>The Pentaerythritols</u>, ACS Monograph No. 136, Reinhold Publishing Corporation, New York, 1958.

82See footnote 1, page 10.

### AMCP 706-177

### Tritonal, 80/20

Composition:	Molecular Weight:	81
%- 1117 მს	Oxygen Belence: CO <sub>2</sub> %	-77
Aluminum 20	CO %	-38
	Density: gm/cc Cast	1.72
	Molting Faint: *C	
C/H Rotio	Freezing Point: "C	
mpact Sensitivity, 2 Kg Wt: Burecu of Mines Apparatus, cm 85	Boiling Point: "C	
Somple Wt 20 mg Picatinny Arsenal Apparatus, in. 13	Refrective Index, no	
Sample Wt, mg 16	n	
Friction Pendulum Test: Steel Shoe Unsflected	Vecuum Stability Test:	
Fiber Shoe Unaffected	cc/40 Hirs, at 90°C	
	100°C	0.1
Rifie Bullet Impact Test: Triais	120°C	0.2
% Explosions 60	135°C	••
Partials 0	150°C	0.8
Burned 0	200 Grem Bomb Sand Test:	
Unaffected 40	Sond, gm	
xpleelen Temperature: •C	Sensitivity to Initiation:	
Seconds, 0.1 (no cap used) 610	Minimum Detonating Charge, gm	
1 520 5 Decomposes 470	Mercury Fulmingte	
10 465	Leod Azide	0.20
15	Tetryl	0.10
20	Ballistic Mortor, % TNT: (a)	124
S'C International Heat Test:	Treuzi Test, % TNT: (b)	125
% Loss in 48 Hrs	Plate Dent Test: (c)	
	Method Condition	B Cast
IOO*C Heat Test:	Contined	No
% Loss, 1st 48 Hrs	Density, gm/cc	1.75
% Loss, 2nd 48 Hrs Explosion in 100 Hrs	Brisonce, % TNT	93
		ی <i>د</i>
Semmebility Index: 100	Confinement None	None
	Condition Cast	Pressed
Hygrescepicity: % 30°C, 90% RH 0.00	Charge Diameter, in. 1.0	1.0
Vələtility:	Density, gm/cc 1.71	1.72
	Rote, meters/second 6475	67 <b>00</b>

### Tritonal, 80/20

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(					
Beaster Sensitivity Test: Condition	(đ)	Cast	Decomposition Equation: Oxygen, atoms/sec		
Tetryl, gm		100	(Z/sec)		
Wax, in. for 50% Detan	ation	0.58	Heat, kilocalorie/mole		
Wox, gm			(AH, kcai/mol) Temperature Range, *C		
_ · •		1.75			
Density, gm/cc		1.17	Phase		
Heat of:	(c)	4480	Armer Plate Impact Test: (	e)	
Combustion, col/gm				•	
Explosion, col/gm		1770	60 mm Merter Projectile:		
Gas Volume, cc/gm			50% Inert, Velocity, ft/sec	509	>1100
Formation, cal/gm			Atuminum Fineness	100	12
Fusion, cot/gm					
	4.5		_ 500-Ib General Purpose Bomb	<b>I:</b>	
	(b)		New Thisteney Jackson	metal a	d Tranh
At -5°C		0.23	Plote Thickness, inches	Trials	<u>§ Inert</u>
Density, gm/cc		1.74	1	0	
			11/4	• 6	100
At 20°C		0.31	11/2	6	33
			134	õ	
Burning Rate:				v	
cm/sec					
			Somb Drop Test: (c)		
Thormaí Conductivity:		1			
col/soc/cm/°C Density, gm/cc	(b)	11 x 10 <sup>-4</sup> 1.73	T7, 2000-b Semi-Armer-Pierc	ing Somb vs	Concrete:
Coefficient of Expension:			Max Safe Drop, ft		
Linear, %/°C			500-Ib General Purpose Bomb		
Volume, %/*C			Height, ft	<u>Seal</u> 4,000	Seal 5,000
			Tricls	34	14
Hardness, Mahs' Scale:				32	14
			Unoffected	•	
Young's Medicius:	( <b>b</b> )		Low Order	0	0
E', dynes/cm²		6.67 x 10 <sup>10</sup>	High Order	2	0
E, Ib/inch <sup>2</sup>		$0.97 \times 10^6$			
Density, gm/cc		1.72	1000-Ib General Purpose Bemi	o ve Concrede	
Contenty, grit/CC		- 1 te	Height, ft		Sea1 5.000
Compressive Strength: Ib/in	ch <sup>z</sup> (b)	2340			24
Density, gm/cc	(-/	1.75	Trials		23
			Unoffected		
Vepor Pressure:			Low Order		0
*C mm i	Mercury		High Order		1
			1		

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States -

### AMCP 706-177

### Tritonal, 80/20

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Progmentation Text:	ξ	Shaped Chorge Bilastivaness, THT = 100:
90 mm HE, MJ1 Projectile, Lat WC-91:		Glass Cones Steel Cones
Deroity, gm/cc	1.71	Hole Volume
Charge Wt, M	2.272	Hole Depth
Total No. of Fragments:		Celor: Grav
For TNT	ξΟΊ	Color: Gray
For Subject HE	616	Prinsing Upp: 3P bombs
3 inch HE, M42A1 Projectile, Lot KC-5:		SP CORDE
Density, gm/cc	1.75	
Charge Wt, Ib	0.914	
Tatul No. of Fragments:		
For TNT	514	Method of Londing: Cast
For Subject HE	485	
		Looding Dentity: sm/:x 1.65-1.72
Fregment Velocity: ft/sec At 9 ft	2460	
At 25½ ft	2380	Storege:
Dansity, gm/cc	1.72	Method Dry
		Method Dry
Nest (Relative to THT):	(f)	Hazord Class (Quantity-Distance) Class 9
Air:		Compatibility Group Group I
Peak Pressure	110	
Impuise	115	Exudation
Energy	119	
Air, Confined:		Preparation:
Impuise	130	
	•	Tritonal is propared by adding THT and aluminum separately to a steam-jerksted melt
Under Water:		kettle equipped with a stirrer. Heating of
Pook Pressure	105	the kettle and mixing of the ingredients are
Impulse	118	continued until all the TNT is melted. When the viscosity of the mixture is considered
Energy	1:19	satisfactory (about 85°C), the tritonal is
Underground:		poured into projectiles or bombs the same as TNT.
Peck Pressure	117	145 1 °
Impuise	127	
Energy	136	
Energy	136	

#### Tritonal, 80/20

AMCP 706-177

#### Origin:

The Addition of aluminum to increase the power of explosives was proposed by Escales in 1899 and patented by Roth in 1900 (German Patent 172,327). Some recent studies, directed towards establishment of the optimum amount of aluminum in the THT/Aluminum system, have shown that (1) the blast effect increases to a maximum when the aluminum content is 30% (Ref g); the brisance, as measured by the Sand Test, passes through a maximum at about 17% aluminum (Ref h); in Fragmentation Tests, no maximum is observed, additions of aluminum causing a decrease in efficiency over the entire range from 0% to 70% aluminum (Ref i); and (4) the rate of detonation of cast charges is continuously decrease! by additions of aluminum up to 40% (Ref j). For all practicel purposes \_t is concluded that the addition of 18% to 20% aluminum to THT improves its performance to a maximum. This conclusion is in agreement with that of British workers who measured performance of aluminized THT-mixtures based on extensive Lead Block Test date (Ref k).

Tritonal, consisting of 80% TNT and 20% aluminum, was developed and standardized in the United States during World War II for use in bombs.

#### References:83

2

(a) L. C. Smith and B. H. Eyster, <u>Physical Testing of Explosives</u>, <u>Part III</u>, <u>Miscellaneous</u> <u>Sensitivity Tests</u>, <u>Performance Tests</u>, <u>OSRD</u> Report No. 5746, 27 December 1945.

(b) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Second Revision, MAVORD Report No. 87-46, 26 July 1946.

(c) D. P. MacDougall, Msthods of Physical Testing, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> Tetryl in Boosters, NOL Memo 10,303, 15 June 1949.

(e) Committee of Div 2 and 8, MDRC, Report on HEM and Tritonal, OSRD No. 5406, 31 July 1945.

(f) W. R. Tomlinson, Jr., <u>Blast Effects of Bomb Explosives</u>, PA Tech Div Lecture, 9 April 1948.

(g) W. B. Kennedy, R. F. Arentzen and C. W. Tait, <u>Survey of the Performance of THT/Al on</u> the Basis of Air-Blast Pressure and Impulse, OSRD Report No. 4649, Division 2, Monthly Report No. AES-6, 25 January 1945.

(h) W. R. Tomlinson, Jr., <u>Develop New Hich Explosive Filler for AP Shot</u>, PATR No. 1290, First Progress Report, 19 May 1943.

(i) W. R. Tomlinson, Jr., <u>Develop New High Explosive Filler for AP Shot</u>, FATR No. 1380, Second Progress Report, 12 January 1944.

(j) L. S. Wise, Effect of Aluminum on the Mate of Detonation of TNT, PATR No. 1550, 26 July 1945.

(k) Armament Research Dept, The Effect of Aluminum on the Power of Explosives, British Report AC-6437, May 1944 (Explosives Report 577/44).

83See footnote 1, page 10.

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### Tritonal, 80/20

(1) Also see the following Picatinny Arsenal Technical Reports on Tritoral:

<u>o</u>	3	4	2	<u>6</u>	I	<u>8</u>
1530 1560 2010	1693 2353	1444	1635	1956	17 <b>37</b> 2127	2138

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Veltex No. 448\*

AMCP 706-177

Composition:		Molecular Weight:	261
96 - HMX	70.0	Oxygen Belerce:	
Nitrocellulose (13.15% N)	15.0	CO <sub>2</sub> %	-26
Ni troglycerin	10.7	CO %	-0.5
2-Nitrodiphenylamine	1.3	Banaitus an /aa Duaaaad	1 70
Triacetin	3.0	Density: gm/cc Pressed	1.72
		Melting Point: *C	
C/H Ratio		Freezing Point: *C	
Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm		Boiling Point: "C	
Sample Wt 20 mg Picatinny Arsenal Apparatus, in.		Refrective Index, na	
Sample Wt, mg		ng	
		n <b>5</b>	
Friction Pendulum Test:		Vacuum Stability Test:	
Steel Shoe	Unaffected	cc/40 Hrs, at	
Fiber Shoe	Unaffected	90°C	****
Rifle Builet Impoct Test: Trials			1.20
• • • • • • • • • •		120°C 29 hours	11+
% Explosions		135°C	
Partials		150°C	
Burned			
Unaffected		200 Gram Bamb Sand Test:	
Unarrected	····	Sand, sim	66.4
Explosion Temperature: "C		Sensitivity to Initiation:	
Seconds, 0.1 (in: cop used)		Minimum Detonating Charge, gm	
1		Mercury Fulminate	****
5		Leod Azide	0.30
10		Tetryl	
15		Ballistic Mortar, % TNT:	
20			<u> </u>
75°C International Hoot Test:		Trouzi Test, % TNT:	,
% Loss in K9 Hrs		Plate Dent Test: Method	
90 °C Heat Test:		Condition	
% Loss, 1st 48 Hrs	0.28	Confined	
% Loss, 2nd 48 Hrs	1.12	Density, gm/cc	
Explosion in 100 Hrs	None	Brisonce, % TNT	
		- Detenetion Rate:	
Flammability Index:		Confinement	
		Condition	
Hygroscopicity: %		Charge Diameter, in.	
		Density, gm/cc	
Voletility:		Rote, meters/second (calculated)	85 <b>00</b>

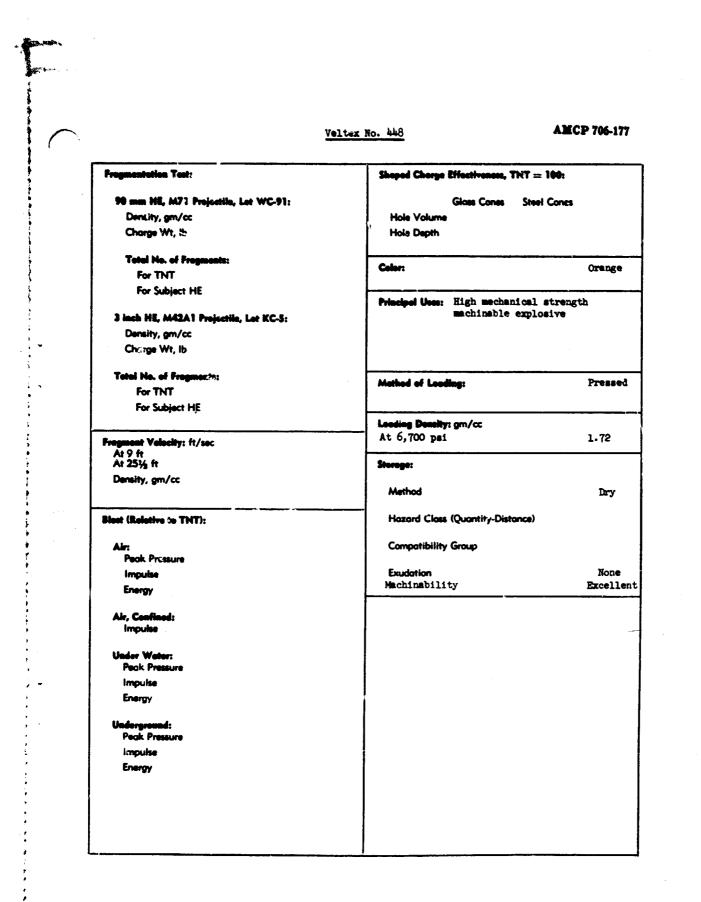
\*See footnote c. following page.

#### AMCP 706-177

The second

### Velter No. 448\*

Beester Sansitivity Test: Condition	Decomposition Equation: Oxygen, atoms/sec
Tetryl, gm	(Z/sec)
Wax, in. for 50% Detonation	Heat, kilocalorie/mole
•	(ムH, kcol/mol) Temperature Ronge, *C
Wax, gm	
Density, gm/cc	Phose
Hest of:	Armer Plate Impact Test:
	- 329
Explasion, col/gm 1	226 60 mm Morter Projectile:
Gas Volume, cc/gm	50% Inert, Velocity, ft/sec
Formation, col/gm	Aluminum Fineness
Fusion, col/gm	
Communication at Duritumes d 8	3.26 Plate Thickness, inches
Work to Produce Rupture:	
ft-lb/inch <sup>3</sup> 9	9.62 114
	11/2
Burning Rate:	
cm/sec	Somb Drup Test:
Thermel Conductivity: col/sec/cm/*C	T7, 2000-16 Semi-Armer-Piercing Bemb vs Concrete:
Coefficient of Expansion:	Max Safe Drop, ft
Linear, %/°C	500-16 General Purpose Bomb vs Concrete:
Volume, %/°C	Height, ft
	Trials
Herdness, Mohs' Scole:	Unoffected
Young's Modulus:	Low Order
E', dynes/cm <sup>2</sup> 0.24 x 1	L0 <sup>10</sup> High Order
E. lb/inch <sup>2</sup> 0.35 x 1	5
Density, gm/cc	1000-16 General Purpose Bomb vs Concrete:
Canality, gm/cc	Height, ft
Compressive Strength: Ib/inch <sup>2</sup> 2	
* <u>***</u>	Unaffectiod
Vapor Pressuro:	Low Order
*C mm Mercury	High Order
*Name assigned by Dr. Mary M. Jones, 1	formerly
of PA; based on original development	
James H. Veltman.	



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### AMCP 706-177

#### Veltex No. 448

#### Preparation:

The preparation of this class of explosive compositions is illustrated by the method used for Veltex No. 448: Place 675 cc of water in a slurry kettle equipped with an agitater. Add 5.85 gm of 2-nitrodiphenylamine and agitate for several minutes to obtain dispersion. Then add 93.7 gm of water-wet nitrocellulose (dry weight 67.5 gm) in small portions. Prise the temperature to  $48^{\circ}$ C and maintain this temperature, but continue the agitation. A mixture of 48.2 gm of nitroglycerin and 13.5 gm of triacetin is added over a 5-minute period, with the mixing continuing for an additional 10 minutes at  $48^{\circ}$ C. The HMX (350 gm) is added over a 5-minute period with agitation continued for 30 minutes at  $48^{\circ}$ C. The slurry is cooled to room temperature and filtered. The filter cake is dried to a moisture content between 8% and 12%. The incorporation of this mix is completed by rolling 50 gm portions at a temperature of approximately 90°C. The finished coll 12 is then preheated on a heat table at  $65^{\circ}$ C. Increments of 25 gm each are pressed at 570 psi for four minutes at 71°C. A cylinder is then built up by pressing together four 25 gm increments for a dwell time of 15 minutes.

#### Origin:

Veltex is the name given to a series of closely related nitrocellulose compositions prepared in 1957 at Picatinny Arsenal by the solventless process used for propellants. These compositions all contain a high percentage of solid high explosive. They were investigated to determinate the suitability of the Holtex type explosive developed by Hispano Suiza of Switzerland, France and Spain, but for which the composition was not reported (Ref a). Compositions similar to Veltex No. 448 and containing 50% to 80% HMX, with either nitroglycerin or triethyleneglycol dinitrate as colloiding agent for nitrocellulose, have also been prepared. In general these compositions showed lower heat stability than that of conventional high explosive compositions.

#### Reference: 84

(a) U.S. Air Intelligence Information Report IR-269-55, Holtex--Hispano Suiza Explosive, 4 May 1955.

84See footnote 1, page 10.

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AMCP 706-177

(AMCRD-TV)

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