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AMC PAMPHLET

AMCP 706-177

ENGINEERING DESIGN HANDBOOK HANDBOOK

EXPLOSIVES SERIES PROPERTIES OF EXPLOSIVES OF MILLTARY INTEREST

REPRODUCED BY NATIONAL TECHNICAL INFORMATION SERVICE U.S. DEPARTMENT OF COMMERCE SPRINGFIELD, VA. 27161

HEADQUARTERS, U.S. ARMY MATERIEL COMMAND

JANUARY 1971

HEADQUARTERS UNITED STATES ARMY MATERIEL COMMAND WASHINGTON, D. C. 20315

AMC PAMPHLET No. 706-177*

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29 January 1971

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ENGINEERING DESIGN HANDBOOK PROPERTIES OF EXPLOSIVES OF MILITARY INTEREST

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PREFACE

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The Engineering Design Handbook Series of the Army Materiel Command is a coordinated series of handbooks containing basic information and fundamental data useful in the design and development of Army materiel and systems. The handbooks are authoritative reference books of practical 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 Explosives of Military Interest, is one of a series on Explosives. One hundred and ten explosive compounds or mixtures are listed herein, alphabetically, 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 first compiled for publication at Picatinny Arsenal, Dover, New Jersey, by W. R. Tomlinson, Jr. These data were later revised by Oliver E. Sheffield, also of Picatinny Arsenal, for the Engineering Handbook Office of Duke University, prime contractor to the Army Materiel 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 release these Engineering Design Handbooks to other 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 AMC and other DOD agencies order direct on an official form from:

Commanding Ufficer Letterkenny Army Depot, ATTN: AMXLE-ATD Chambersburg, Pennsylvania 17201

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

c. Government agencies other than DOD 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

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

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

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

ABBREVIATIONS AND SYMBOLS

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~ approximately. This symbol is used before numbers. AC Advisory Council on Scientific Research and Devilopment, Great Britain. American Chemical Society. American Iron and Steel Institute. ACS ATST Ann Liebig's Annalen der Chemie. Ann chim phys Annales de chimie et de physique. armor-piercing. AP APG Aberdeen Proving Ground. atm atmosphere; atmospheric pressure. Bei1 Beilstein Organische Chemie, 4th Edition. Ber Berichte der Deutschen Chemischen Gesellschaft. BIOS GP2-NEC British Intelligence Overseas Service or Objective Subcommittee, Group 2, Halstead Exploiting Center. BM Bureau of Mines, United States Department of Interior. Bull Soc chim Bulletin de la societé chimique de France. Chemical Abstracts. CA. calc calculated. Chem Met Eng Chemical and Metallurgical Engineering. Chim et Ind Chimie et Industrie. Comptes rendus hebdomadaires des seances de Comp rend l'Academie des Sciences (Paris). centipoise. ¢p CR Comptes rendus hebdomadaires des seances de l'Academie des Sciences (Paris). dec decomposes. difference in heat (i.e., heat evolved) by decomposition. Δн n p p Deutsches Reichspatent. modulus of elasticity or "Young's modulus"; longitudinal Ë stress/change in length; (force/area)/(elongation/ length); expressed in 1b/inch². sama as E, but expressed in dynes/cm². ε' Gazzetta Chimica Italiana. Gazz chim ital GP general purpose. ΗE high explosive. HEAT high explosive antitank. Industrial & Engineering Chemistry. Ind Eng Chem J Am Chem Soc Journal of the American Chemical Society The Journal of the Society of Chemical [Industry (London). J Chem Ind J Chem Soc Journal of the Chemical Society (London). J Frank Inst Journal of the Franklin Institute. J Ind Explosives Suc Journal of the Industrial Explosives Society (Japan). J prakt Chom Journal für praktische Chemie. lead azide ĭ. A Land-Bornst Landolt-Bornstein Physikalish-Chemische Tabellen, Sth Edition (Berlin). М molar. Monatshefte für Chemie (Wein). N Mém poudr Mémorial des poudres et salpêtres (Paris). ng milligram.

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ABBREVIATIONS AND SYMBOLS (cont'd)

. •

. :

| min | #inimum. |
|-----------------|---------------------------------------------------------------|
| ml | milliliter. |
| u/s | meters per second. |
| HW | molecular weight. |
| NAVORD | Bureau of Ordnance (U. S. Navy) |
| NC | nitrocellulose. |
| D | |
| ⁿ 20 | index of refraction, with D band of sodium as light |
| | source, at twenty degrees cantigrade. |
| NDRC | National Defense Research Committee. |
| NFOC | National Fireworks Ordnance Corporation. |
| NG | nitroglycerin. |
| NOL | U. S. Naval Ordnance Laboratory, White Oak, Silver |
| | Spring, Maryland. |
| NOTS | U. S. Naval Ordnance Test Station, China Lake, Calif. |
| NRC | National Research Council. |
| OB | oxygen balance. |
| OCM | Ordnance Committee Minutes. |
| OSRD | Office of Scientific Research and Development |
| PA | Picatinny Arsenal. |
| PATR | Picatinny Arsenal Technical Report. |
| Phil Trans | Philosophical Transactions of the Royal Society of London. |
| - | |
| Pogg Ann | Poggendorf's Annalen der Physik. |
| Proc Roy Soc | Proceedings of the Royal Society of London. |
| Rec trav chim | Recueil des traveux chimiques des Pays-Bes. |
| RH | relative humidity. |
| RI | Report of Investigation. |
| SAE | Society of Automotive Engineers. |
| SAP | semi-armor-piercing. |
| s ol | solution. |
| Spec | Specifications. |
| std dev | standard deviation. |
| TM | Technical Manual, Department of the Army. |
| TM/TO | joint publication, as a TN and as a Department of the |
| | Air Force Technical Order. |
| | Transactions of the Faraday Society |
| vac stab | vacuum stability. |
| Z angew Chem | Zeitschrift für angewandte Chemie. |
| Z anorg Chem | Zeitschrift für anorganische und allgemeine Chemie. |
| Z ges Schiess- | Zeitschrift für das gesamte Schiess und Sprengstoff- |
| Sprengstoffw | wessen (Munchen). |
| Z/sec | atoms of oxygen per second. |
| | |

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PROPERTIES OF EXPLOSIVES OF MILITARY INTEREST

INTRODUCTION

1. PREDOMINANTLY A REPORT OF STANDARD TESTS. No effort was made to cover all the existing literature, either open or classified security information, on any explosive. Father, the main resource has been reports from facilities using standard or 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, deted April 1958, with revisions, provides the data used herein.

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

4. <u>REFERENCE NOTATIONS AND SOURCES.</u> The references, as to sources of data or for more details in methods of testing, have been listed, when available, at the end of each section devoted to a given explosive 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 additional information on the particular explosive. 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 METHODS 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.

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- (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 weight 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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height at which at least one of 10 trials results in <u>explosion</u>. For the EM apparatus, the unit of height is the centimeter; for the PA apparatus, it is the inch. In the formor, the explosive is held between two flat, parallel hardened ($C(3 \pm 2)$ steel surfaces; in the latter case, it is placed in the depression of a small steel die-cup, capped by a thin brass cover, in the center of which is placed a slotted-vented-c-lindrical steel plug, slotted side down. In the EM 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 test (1) involves greater confinement, (2) distributes the translational impulse over a smaller ares (due to the inclined sides of the die-cup cavity), and (3) involves a frictional component (against the inclined sides). ١.

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The test value obtained with the PA apparatus depends, to γ 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 herein 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) Tapact sensitivity test for liquids. (b)

The PA Impact Test for liquids is run in the same way as for solids. The die-cup is filled and the top of the liquid meniscus 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 wet the die-cup rim after the trass 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 BM 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, show avinging as a pendulum at the end of ε long steel rod. The behavior of the sample is described qualitatively to indicate its reaction to this experience, i.e., the most energetic reaction is explosion, and in decreasing order of severity of reaction: snaps, cracks, and unaffected.

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

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, 1/16inch 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 plug. 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.

3

(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 chort period in a <u>Wood's metal</u> bath. The temperature determined is that which produces explosion, ignition or decomposition 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 diructly 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.

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

A 10-gm sample is heated for 48 hours at 75° C. The sample after this exposure is observed for signs of decomposition or volatility.

(8) "100⁰C Heat Test." (a)

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A 0.6-gm sample is heated for two 49-hour periods at 100° C. It is also noted whether exposure at 100° C for 100 hours results in explosion.

(9) "Flammability Index." (h)

The measure of the likelihood that a bare 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) "Hygroscopicity."

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 10-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 (MW) of a mixture can be calculated from the equation

MW of mixture =
$$\frac{100}{\frac{a}{mW_1} + \frac{b}{mW_2} + \frac{c}{mW_3} + \frac{n}{mW_n}}$$

where a, b, c and n are the weight percents of the components, and mw_1 , mw_2 , mw_3 and mw_n their corresponding molecular weights.

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(13) "Oxygen Balance."

The oxygen balance (OB) is calculated from the empirical formula of a compound in percentage of oxygen required for complete conversion of carbon to carbon dioxide (or carbon wonoxide) and hydrogen to water. When metal is present the reactions are assumed to occur in the following order:

> Metal + 0 \longrightarrow Metal Oxide C + H₂O \longrightarrow CO + H₂ CO₂ + H₂ \longrightarrow CO + H₂O 2CO + O₂ \longrightarrow 2CO₂

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

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

 \div molecular weight of compound = oxygen balance to CO₂ and H₂O, where X = atoms of carbon, Y = atoms of hydrogen, Z = atoms of oxygen. The oxygen balance of a mixture is equal to the sum of the percent composition times the oxygen balance for each component.

The carbon/hydrogen (C/H) ratio is calculated as follows:

Number of C atoms $(\frac{4}{3}C + \frac{4}{3}H) = C/H$ ratio Number of H atoms (100)

- (14) "Density."
- (15) "Melting Point."
- (16) "Freezing Point."
- (17) "Boiling 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 cap, 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 crushes the maximum net weight of sand, is designated as its <u>sensitivity to initiation</u> and the net weight of sand crushed, finer than

5

30 mesh, is t rmed the <u>sand test value</u>. The net weight of sand crushed is obtained by subtracting from the total the amount crushed by the initiator when shot alone.

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(b) Sand test for liquids. (b)

The sand test for liquids is made in accordance with the procedure given for solids except that the following procedure for loading 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 azide 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 squeering 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 adheres 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 diameter 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 exerting 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 lesd azide into the aluminum cap containing the fuse and explosive charge of tetryl and lesd azide into the aluminum cap containing the fuse and 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 grams, required to detonate the explosive sample, is given.

(22) "Ballistic Mortar, % TMT." (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 (INT) is determined. The sample is then rated, on a proportionate basis, as having a certain INT value, i.e., as being a certain percent as effective as INT in this respect. The formula is

INT value =
$$\frac{10}{\text{sample weight}} \times 100.$$

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 projectilu 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 raised by the explosion, and this latter represents the energy measured by this test procedure.

(23) "Trauzl Test, % TNT." (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 upper face of each block, which is cast in a mold from desilverized lead of the best quality. Although these tests have been made under a variety

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 of Nacum's test. Thus expansions for equivalent weights were readily calculated, and the test value 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 - The charge is contained in a copper tube, having an internal diameter 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 is 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 dismeter, 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 as 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 | = <u>Sample Dent Depth</u> x 100. Dent Depth for TNT at 1.61 gm/cc |
|------------------------|----------------------|-----------------------------------------------------------------------|
| | | Bene Behar set wit no Trat Bud an |

(25) "Detomation 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 0.995 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.

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

The booster sensitivity test procedures 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 Acravax B, 1-5/8 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 Boms, approximately 45 cc (for high loading density). For

7

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.

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- (3) "Specific Heat."
- (4) "Burning Rote."
- (5) "Thermal Conductivity."
- (6) "Coefficient of Expension."
- (7) "Hardness, Mohs' Scale."
- (8) "Young's Modulus."
- (9) "Compressive Strength."
- (10) "Vapor Pressure."
- (11) "Decomposition Equation."
- (12) "Armor Plate Impact Test." (j)
 - (a) 60-mm Nortar Projectile.

A modified 60-mm, N49A2, mortar projectile is loaded with the explosive to be tested, drilled to the proper depth (about 1/2 inch), and a flat-based stoel plug screwed into the projectile to give a smooth close-fit between the plug base and the clarge. The part of the plug outside the projectile is rounded off in the form of a spherical solution. The loaded projectile with fins attached is fired from a five foot length of $2^{-5}/8$ 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 black puscer, 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, inert 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/sac, the 50% point is located.

(b) 500-1b General Purpose Bombs.

(13) "Bomb Drop I tt."

Bomb drops are made using bombs assembled in the conventional manner, as for service usage, but containing either 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 M2O Booster peliets, and those used with 3-inch HE, M42A1, Lot KC-5 and 90-mm HE, M71, Lot WC-91 projectiles are controlled in weight and height as follows: 22.50 ± 0.10 gm, and 0.480 to 0.485 inch.

1 is

The projectile assembled with fuze, actuated by a Plasting Cap, Special, Type II (Spec 19 -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 fragmented 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 steel fragmentation tub, the detonator wires are connected, and the box covered with approximately 4 feet more of sand. The projectile is fired und the sand run onto a gyrating 4-mesh screen on which the fragments are recovered.

(2) "Fragment Velocity."

Charges 10-1/8 inches long and 2 inches in diameter, 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 JD, 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 tourmaline gages, and the usual necessary specialized electrical circuits, shielded co-axial cables, oscillographs, etc. In general, the data represent results of tests with large cased charges.

(4) "Shaped Charge Effectiveness, TNT = 100." (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 cone) of cast 60/40 cyclotol, are shot egainst 3-inch homogeneous armor plate at a 1-3/16 inches standoff. The course are commercial Pyrex glass finnels, sealed off at the start of the stem, 2 inches in diameter, 0.110 to 0.125 inch wall thickness.

Unconfined charges 1.63 inches in diameter and 6 inches long are tested at a standoff of 1.63 inches sgainst stacks of $4 \times 4 \times 1$ inch mild steel plates. M9A), steel cones are used. Results are averages of 4 trials.

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

Ammunition 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) Method: Wet or dry.
- (b) Hazard Class (Quantity-Distance).

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

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(c) Compatibility Group.

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

1. Effects of explosion of the item.

2. Rate of deterioration.

3. Sensitivity to initiation.

4. Type of packing.

5. Effects of fire involving the item.

6. Quantity of explosive per unit.

(d) Exudation.

d. Miscellaneous entries.

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

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(1) Solubility.

(2) Methods of manufacture.

- (3) Historicel information.
- (4) Bulk compressibility modulus. (q)

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 a' the Naval Ordnance Laboratory and is described in detail in Reference q. Bulk modulus (its reciprocal is the compressibility) is defined as the ratic of stress to strain when the stress is a pressure applied equally on all surfaces of the sample and the strain is the resulting change in volume per unit volume.

(5) Hydrolysis tests. (o)

The 240-hour hydrolysis test is conducted as follows: A 5-gm sample of the dry nitrocellulose is weighed accurately in a tare-weighed 250-cc 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 by 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 initiation by electrostatic discharge. (n)

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 is 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 ($\sim 7 \text{ mm ID x}$ 18 mm long) which fits over a metal peg. The volume of the space around the charge at zero gap is ~ 0.15 cost st a gap of 0.6 mm, it is ~ 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 being repelled 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 morcury 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 explosives. 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 filminate and nitrogly-cerls.

(8) Other information.

(9) References.

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Amatol, 80/20

7.

| Composition: % | ł | Moleculor Weigha: | | 92 , |
|-----------------------------------------------------------------------------|------------|----------------------------|--------------------|---------------------------------------|
| | | Oxygen Balance: | | |
| Ammonium Nitrate | 80 20 | CO, % | | +1 |
| TNT | 20 | CO % | + | 11 |
| | | Density: gm/cc Ga | st 1. | 46 |
| | | Molting Point: "C | | |
| C/H Rotio | <u> </u> | Freezing Point: "C | | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 90 | Boiling Point: *C | | · · · · · · · · · · · · · · · · · · · |
| Sample Wt 20 mg | • | Refractivo Index, ng | • | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 15 17 | n ^o | | |
| Sample Wi, ing | ↓ (| n | | |
| Friction Pendulum Test: | | Vacuum Stability Test: | | |
| Steel Shor Unaffe | | cc/40 Hrs, at | | |
| Fiber Shoe Unaffe | eted | 90°C | | 1 |
| Rifle Bullet Impact Test: 5 Triais | | 100.0 | | 45 |
| % | | 120°C | 0. | 95 |
| Explosions 0 | | 135•C | | 0 |
| Partials 0 | | 150°C | 6. | • |
| Burned 0 | | 200 Grem Bemb Sand Tout: | | |
| Unoffected 100 | | Sand, gm | 35. | 5 |
| Explosion Temperature: *C | | Sonsitivity to Initiation: | | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Cho | orge, gm | |
| 1 5 Decomposes 280 | | Mercury Fulminate | | |
| | ţ | Leod Azide | ٥. | 20 |
| 10 | | Tetryi | 0, | 07 |
| 15 | | Ballistic Mortur, % TNT: | (a) 13 | n |
| 20 | | | (b) 12 | |
| 75°C International Heat Test: | | Piete Dent Test: | (0) 10 | |
| % Loss in 48 Hrs | 0.06 | Method | | |
| 100°C Huat Test: | | Condition | | |
| % Loss, 1st 48 Hrs | 0.03 | Confined | | |
| % Loss, 2nd 48 Hrs | 0.05 | Density, gm/cc | | |
| Explosion in 100 Hrs | None | Brisance, % TNT | | |
| | | Detenation Rets; | 97 . 27 | |
| Fiammability Index: | | Confinement | 1'one | stone |
| A8 | | Condition | (18) | Cast |
| Hygroscepicity: % 30°C, 90% RH, 2 days | 61 | Charge Diameter, in. | 1.0 | 2.0 |
| | N11 | Density, gm/cc | 1.46 | 2173 |
| Veletility: | NIT | Rote, meters/second | 4500 | 5100 |

Aumatol, 80/20

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| Fregmentation Test: | Shapud Charge Effectiveness, TNT = 100: |
|-------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, lb | Glazs Cones Steel Cones Hole Volume Hole Depth |
| Total No. of Fragmonts: For TNT | Color: Buff-yellow |
| For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: | Principal Uses: Bozba, HE projectiles |
| Density, gm/cc Charge Wt, Ib | |
| Total No. of Fragmonius: For TNT For Subject HE | Method of Londing: Cast |
| Fregment Velocity: ft/sec (1) | Looding Density: gm/cc 1.46 |
| At 9 ft 1900 At 25½ ft 1750 | Storage: |
| Denuity, gm/cc | Method Dry |
| Binst (Relative to TNT); | Hazard Class (Quantity-Distance) Cluss 9 |
| Air: Peak Pressure | Compatibility Group Group I |
| Impulse Energy | Exudation Does not exude at 65°C |
| Air, Confined: impulse | Booster Sensitivity Test: (a) |
| Under Weter: Peak Pressure | Condition Pressed Twtryl, gm 100 Wax, in. for 50% Detonation 0.83 Density, gm/cc 1.65 |
| impulse Energy | Heat of: (d, e) |
| Underground: Peak Pressure Impulse Energy | Combustion, cal/gm 1002* Explasion, cal/gm 490* Gas Volume, cc/gm 930* |
| | |
| | *Calculated from composition of mixture. |

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Amatol, 60/40

| Composition: 96 | | Molecular Weight: | 108 |
|-------------------------------------------------------------------------------------------------------|----------------|----------------------------------------------------------------------------------|--------------|
| 70 Anmonium Nitrate INT | 60 40 | Oxygen Balance: CO2 % CO % | -18 + 2 |
| | | Density: gm/cc Cast | 1.60 |
| | | Melting Peint: "C | |
| C/H Ratio | | Freezing Paint: "C | |
| Impact Sensitivity, 2 Kg Wt: | | Bailing Point: "C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arschal Apparatus, in, Sample Wt, mg | 95 16 17 | Refrective Index, nº nº nº | |
| Friction Pendulum Test: Steel Shoe Fiber Shoe | | Vocuum Stability Tost: cc/40 Hrs, at 90°C | |
| Rifle Bullet Import Test: Trials % Explosions Partials | | 100°C 120°C 135°C 150°C | |
| Burned Unaffected | | 200 Grem Bomb Sand Test: Sand, gm | 41.5 |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 | | Sencitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate | |
| 5 Decomposes 270 | | Leod Azide | 0.20 |
| 15 | | Tetryl | 0.06 |
| 20 | | Bollistic Mortov, % TNT: (=) | 128 |
| 75°C International Heat Test: % Loss in 48 Hrs | | - Trouxi Test, % TNT: Plote 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 | |
| Flammability Index: | | Confinement | None |
| Hygroscopicity: % | | Condition Charge Diameter, in. | Cast 1.G |
| Vcletility: | NIL | Density, gm/cc Rate, maters/second | 1.50 5760 |

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Amato1, 60/40

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| Fragmentation Test: | | Shaped Charge Effectivenese, TNT = 100: |
|--------------------------------------|--------|--------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot \ | WC-91: | Glass Cones Steel Cones |
| Density, gm/cc | 1.49 | Hole Volume |
| Charge Wt, Ib | 1.971 | Hole Depth |
| Total No. of Fragments: | | |
| For TNT | 703 | Color: Buff-yellow |
| For Subject HE | 583 | Principal Uses: Bomba, HE projectiles |
| 3 lach HE, M42A1 Projectile, Let | KC-5: | Frincipal Usos: Bombs, HE projectiles |
| Density, gm/cc | 1.57 | |
| Charge Wi, Ib | 0.827 | |
| Total No. of Fragments: | | Mashed of Los firms |
| For TNT | 514 | Method of Looding: Cast |
| For Subject HE | 408 | |
| | | Loading Density: gm/cc 150 |
| Fregment Velocity: ft/sec At 9 ft | | |
| At 2514 ft | | Sierage: |
| Density, gm/cc | | Method Dry |
| Blast (Relative to ThIT): | | Hazard Class (Quantity-Distance) Class 9 |
| Air: | | Compatibility Group Group I |
| Peak Pressure | 95 | |
| impulse | 85 | Exudation Does not exude at 65°C |
| Energy | 24 | |
| Air, Confined: | | Heat of: (d, e) |
| Impulse | | Combustion, cal/gm 1658* |
| Under Weter: Peak Pressure | | Explosion, cal/gm 633* Gas Volume, cc/gm 880* |
| Impulse | | |
| Energy | | |
| Underground: Peak Pressure | | |
| impulse | | |
| Energy | | |
| | | |
| | | *Calculated from composition of mixture. |
| | | |

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Amatol, 50/50

| Composition: % | Melecular Weight: | 118 | | | | |
|------------------------------------------------------------------|----------------------------------|--------------------|--|--|--|--|
| ~ Ammonium Nitrate 50 TNT 50 | Caygon Balanze: CO: % CO % | -27 - 3 | | | | |
| | Bensity: gm/cc Cast | 1.59 | | | | |
| | Melting Paint: *C | | | | | |
| C/H Ratio | Freezing Paint: *C | | | | | |
| Impact Seasitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 95 | Sailing Point: "C | | | | | |
| Sample Wt 20 mg | Refractive Index, ng | | | | | |
| Picationy Arsenal Annanatus, in. 16 Sample Vit, mg 17 | ng | | | | | |
| | ng | | | | | |
| Friction Pondulum Test: | Vocuum Stability Test: | | | | | |
| Steel Shoe Unit fecte | 667 48 1 110, 61 | | | | | |
| Fiber Shoe Unaffecte | r g | | | | | |
| Ritte Buildt Impact Test: Triais | 100°C | 0.2 | | | | |
| * | 120°C | 1.0 | | | | |
| Explosions 0 | 135°C | | | | | |
| Partials 0 | 150.0 | | | | | |
| Burned 0 | 200 Gram Bomb Sand Toot: | | | | | |
| Unaffected 200 | Sond, gm | 42.5 | | | | |
| Explosion Temperature: *C | Sanshivity to Initiation: | | | | | |
| Ssconds, 0.1 (no cap used) | Minimum Detonating Charge, g | jm | | | | |
| 1 | Mercury Fulminate | | | | | |
| 5 Decomposes 265 | Leod Azide | 0.20 | | | | |
| 10 | Tetryl | 0.05 | | | | |
| 15 | Bailletic Martar, % TNT: (a) | 124 | | | | |
| 20 | Trucal Test, % TNT: | | | | | |
| 75°C International Heat Test: | Plate Deat Test: | ~ | | | | |
| % Loss in 48 Hrs | Method | B | | | | |
| 100°C Heet Test: | Condition | Cast | | | | |
| % Loss, 1st 48 Hrs | Confined | No | | | | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | 1.55 | | | | |
| Suplasion in 100 Hrs | Brisonce, % TNT | 52 | | | | |
| Man and Miller for James | Deteneties Rate: | | | | | |
| Fismmability Index: | | ne None st Cast | | | | |
| Hygrescapicky: 95, N11 | Charge Diometer, in. 1. | | | | | |
| Walaatilaa. | Density, gm/cc 1. | 55 1.55 | | | | |
| Veletility: | Rate, meters/second 64 | 30 6230 | | | | |

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AMCP 706-177 Amatol, 50/50 Shaped Charge Effectivences, TNT = 100: ر نحر به **Fregmentation Test:** Glass Cones Steel Cones (g) 90 mm HE, M71 Projectile, Lot WC-91: . . ! Density, gm/cc 1.55 Hole Volume 53 lapp. . 2.053 Charge Wt, Ib Hole Depth 69 à. Total No. of Fragments: Coler: Buff-yellow For TNT 703 630 For Subject HE Principal Uses: Bombs, HE projectiles 3 inch HE, M42A1 Projectile, Lot KC-5: 1.54 ... Density, gm/cc Charge Wt, Ib 0.819 **Total No. of Freqments:** Method of Locding: Cast For TNT 514 For Subject HE 385 Looding Density: gm/cc 1.59 Fragment Velocity: ft/sec At 9 ft At 25 1/2 ft Storage: Density, gm/cc Method Dry Hozard Class (Quantity-Distance) Class 9 Blast (Relative to TNT): Compatibility Group Group I Air: Peak Pressure 97 Exudation Does not exude at 65°C Impulse 87 Energy Booster Sensitivity Test: (=) Air, Confined: Condition Cast Impulse Tetryl, gm 100 Wax, in. for 50% Detonation Density, gm/cc 0.60 1.55 Under Water: Peak Pressure (đ, e) Heat of: Combustion, cal/gm 1990 Impulse Explosion, cal/gm 703* Energy 98 Gas Volume, cc/gm 855* *Calculated from composition of mixture. Underground: Specific Heat: cal/gm/°C Temp, 20% to 80°C Peak Pressure 104 **(i)** 0.383 104 Impulse 104 Bomb Drop Test: Evergy T7, 2000-1b Semi-Armor-Piercing Bomb vs Concrete: Max Safe Drop, ft 4000-5000

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Amatols 80/20, 60/40, 50/50

Compatibility with Metals:

Nry - Metals unaffected are zinc, iron, tin, brass, brass tin plated, brass NRC costed, brass shellac coated, nickel aluminum, steel, steel plated with nickel, zinc or tin, stainless steel, Farkerized steel, and steel coated with acid-proof black paint. Metals slightly affected are copper, bronze, lead and copper plated steel.

Preparation:

In preparing amatols the proper granulation of ammonium nitrate is required if the maximum density of the cast amatol is desired. The ammonium nitrate 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 shell 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. Eyster, <u>Physical Testing of Explosives</u>, <u>Part III</u>, <u>Miscellaneous</u> <u>Sensitivity Tests</u>, <u>Performance Tests</u>, OSRD Report 5746, 27 December 1945.

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

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

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

(d) Committee of Div 2 and 8, NDRC, <u>Report on HBX and Tritonal</u>, OSRD Report No. 5406, 31 July 1945.

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

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

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

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

| <u>o</u> | 1 | 2 | 3 | <u>4</u> | 2 | <u>6</u> | 1 | 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 1783 | 364 694 734 874 1344 | 65 425 695 715 735 1145 1225 1345 1455 1885 | 266 556 660 986 1376 1446 1636 1796 | 1207 1457 1797 1827 2167 | 548 638 838 1098 1148 1388 1568 1838 | 549 799 920 1129 1219 1369 1559 |

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

²See footnote 1, page 10.

Ammonal

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| Composition: | | Meleculer Weight: | 102 |
|---------------------------------------------------------------|----------|-------------------------------|--------------|
| % Ammonium Nitrate TNT | 22 67 | Oxyg n Belance: C | - 55 - 22 |
| Aluminum | 11 | Density: gm/cc Cast | 1.65 |
| | | Meiting Point: "C | · / |
| C/H Ratio | | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 91 | Boiling Point: *C | |
| Sample Wt 20 mg | | Refrective Index, nm | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 11 19 | nB | |
| | | n S | |
| Friction Pandulum Test: | | Vecuum Stebility Test: | |
| Steel Shoe | | cc/40 Hrs, at | |
| Fiber Shoe | | 90°C | |
| Rifle Bullet Impact Test: Trials | | 100°C | 1. I. |
| % | | 120°C 135°C | 14 . l4 |
| Explosions | | 135°C 150°C | |
| Partials | | | |
| Burned | | 200 Grem Bomb Sand Test: | |
| Unaffected | | Sand, gm | 47.8 |
| Explosion Temperature: *C | | Sunsitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | | Mercury Fulminate | 0.20 |
| 5 Decomposes 265 | | Lead Azide | |
| 10 15 | | Tetryi | • |
| 20 | | Ballistic Mortor, % TNT: (a) | 122 |
| 2V | | Trouxi Test, % TNT: | |
| 75°C International Heat Test: | | Piete Dent Test: | |
| % Loss in 48 Hrs | | Method | |
| 100°C Heet Test: | | Condition | |
| % Loss, 1st 48 Hrs | 0.00 | Confined | |
| % Loss, 2nd 48 Hrs | 0.10 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisonce, % TNT | |
| | | Detenation Rate: | |
| Flammability Index: | | Confinement | |
| Hygroscopicity: % | | Condition | |
| 117314-000-000-000-000-000-000-000-000-000-0 | | Charge Diameter, in. | |
| Veletility: | | Density, gm/cc | |
| • | | Rate, metars/second | |

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Ammonal

| Fregmentation Test: | Sheped Charge Affectivaness, TNT == 190: |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lat WC-91: Density, gm/cc Charge Wt, ib | Glass Corres – Steel Cones Hole Volume Hole Depth |
| Totol No. of Fragments: For TNT | Color: |
| For Subject HE 3 inch HE, M42A'l Projectile, Let KC ₇ 5: Density, gm/cc 1.65 Charge Wt, Ib | Principal Uses: Projectile filler |
| Total No. of Fragments: For TNT 655 For Subject HE 550 | Method of Looding: Cast |
| | Loadiny Density: gm/cc 1.65 |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Storage: Method Dry |
| Slast (Relative to TNT): Air: Peak Pressure Impulse Energy | Hazard Class (Quantity-Distance) Class 9 Compatibility Group Exudation |
| Air, Confined: Impulse Under Weter: Peak Pressure | Origin: Castable mixture developed in United States during World War I. References: |
| Impulse Evergy | (a) W. R. Tomlinson, Jr., <u>Physical and Explosive Properties of Military Explosives</u> , PATR No. 1372, 29 November 1943. |
| Underground: Peak Pressure Impulse Energy | (b) Also see the following Picatinny Arsenal Technical Reports on Ammonals: 1108, 1286, 1292, 1308 and 1783. |
| Preparation: Procedure same as described under Amstols, except aluminum is added to the summonium ni- trate-TNT molten mixture under agication un- til uniformity in composition is obtained. Loading is accomplished by pouring into the supporties of the supering of | |

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Ammonium Nitrate

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| Composition: 96 | | Molocular Weight: (H ₄ H | 2 ⁰ 3) | 80 | |
|--------------------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------|-------------------|------------|--|
| N 35 | NU. NA | Oxygen Balance: CO ₂ % CO % | | +20 +20 | |
| н 5 | NHI NO3 | Density: gm/cc Cryst | •1 | 1.73 | |
| 0 60 | | Melting Point: *C | | 170 | |
| C/ + Ratio | | Freezing Point: *C | <u> </u> | | |
| mpact Sensitivity, 2 Kg Wt: | 100+ | Boiling Point: "C | | | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | 2007 | Refrective Index, no | | | |
| Picatinny Arsenal Apparatus, in | 31 | ពង | | | |
| Sample Wt, mg | 17 | n _{pe} | | | |
| Friction Pendulum Test: | | Vacuum Stability Test: | | | |
| | ffected | cc/40 Hrs, at | | | |
| Fiber Shoe Una | ffected | 90°C | | | |
| Rifle Bullet Impact Tests Trials | ************************************** | 100°C | | 0.3 | |
| | • | 120°C | | 0.3 | |
| Explosions 0 | | 135°C | | | |
| Partials Q | | 150°C | | 0.3 | |
| Burned O | | 200 Grem Romb Sead Test | | | |
| Unaffected 100 | | Sand, gm | | N11 | |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 | | Sensitivity to Initiation: Minimum Detonating Cl Mercury Fulminate | harge, gm | | |
| 5 Ignites 465 | | Leod Azide | | 0.20 | |
| 10 | | Tetryl | | 0.25 | |
| 15 | | | | | |
| 20 | | Beilistic Morter, % THT: | (*) | 56 | |
| 75°C International Heat Test: (a) | | Treuxi Test, % TNT: | | | |
| % Loss in 48 Hrs | · 0.0 | Piete Dent Test: · Method | | | |
| 100°C liest Test: | | Condition | | | |
| % Loss, 1st 48 Hrs | 0.74 | Confined | | | |
| % Loss, 2nd 48 Hrs | 0.13 | Density, gm/cc | | | |
| Explosion in 100 Hrs | None | Brisance, % TNT | | | |
| Flammability Index: | | Detenction Retu: Confinement | (b) None | Strong | |
| | | Condition | Solid | Liquid | |
| Hygroscopicity: % 30°C, 90% RH | Extreme | Charge Diameter, in. | 1.25 | 4.5 | |
| Veletility: | | Density, gm/cc | 0.9 | 1.4 | |
| Decomposes | at 210°C | Rate, meters/second | 1000 | 2500 | |

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Ammonium Nitrate

| Beaster Sensitivity Test: Condition | | Decomposition Equation: (1) Oxygen, atoms/sec 1013.8 (h) 12.3 | | | | |
|--------------------------------------------------|-------|------------------------------------------------------------------|--|--|--|--|
| Tetryl, gra | | (Z/sec) | | | | |
| Wax, in. for 50% Detonation | | Heat, kilocalorie/mole 40.5 38.3 (ΔΗ, kcal/mol) | | | | |
| Wax, gm | | Temperature Range, *C 243-261 217-267 | | | | |
| Density, gm/cc | | Phose Liquid | | | | |
| Hout of: | 346 | Armer Plets Impect Test: | | | | |
| Combustion, col/gm | 346 | | | | | |
| Explosion, col/gm | 980 | 60 mm Morter Projectile: | | | | |
| Gas Volume, cc/gm Formation, cal/gm | 1098 | 50% Inert, Velocity, ft/sec | | | | |
| Fusion, col/gm | 18.23 | Aluminum Fineness | | | | |
| Fusion, cor/gm | 10.20 | 500-16 General Purpose Bombs: | | | | |
| Specific Heat: cal/gm/*C (| e) | | | | | |
| <u>°c</u> | , | Plate Thickness, inches | | | | |
| | • 397 | | | | | |
| -100 0.330 50 0 | .414 | 1 | | | | |
| -50 0.364 100 0 | . 428 | 11/4 | | | | |
| | | 11/2 | | | | |
| | | 1% | | | | |
| Burning Rute: cm/sec | | | | | | |
| City Sec | | Somb Drop Test: | | | | |
| Thermal Conductivity: cal/sec/cm/*C 2.9-3.9 x | 10-4 | 17, 2000-16 Semi-Armor-Piercing Bomb vs Concrete: | | | | |
| Coefficient of Expension: | | Max Safe Drop, ft | | | | |
| Linear, %/°C | | 500-lb General Purpose Bomb vs Concrete: | | | | |
| Volume, %/*C | | Height, ft | | | | |
| | | Trials | | | | |
| Hardness, Mohs' Scala: | | Unaffected | | | | |
| ······································ | | Low Order | | | | |
| Young's Modulus: | | High Order | | | | |
| E', dynes/cm² | | | | | | |
| E, Ib/inch ² | | 1000-16 General Purpose Bernh vs Concretu: | | | | |
| Density, gm/cc | | 14-1-1- A. A. | | | | |
| Con. resive Strength: Ib/inch [*] | | Height, ft | | | | |
| mere strengtst; 10/ Inch- | | Trials | | | | |
| | ····· | Unaffected | | | | |
| *eper Préssure: (g) *C mm Mercul | ~ | Low Order | | | | |
| | 7 | High Order | | | | |
| 188 3.25 205 7.45 | | | | | | |
| 216 11.55 | | | | | | |
| 223 15.80 237 41:8 | | | | | | |
| 237 21:8 | | | | | | |

Ammonium Nitrate

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| Fragmentation Test: | Shaped Charge Effectiveness, TNT = 300: | | | | | |
|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|--|
| 90 mm HE, M71 Projectife, Let WC-91; Density, gm/cc Charge Wt, Ib | Glass Cones St∡el Cones Hole Volume Hole Dep≀h | | | | | |
| Total No. of Fragmants: For TNT | Colorlezz | | | | | |
| For Subject HE 3 inch Hž, M42A1 Projectile, Lot KC-5: Density, gm/cc Churge Wt, ib | Principal Uses: Explosive ingredient of mixtures used in bombs or large caliber projectiles | | | | | |
| Total No. of Fragments: For TNT For Subject HE | Mathes of Loading: Pressed or cast depending on composition of mixture . | | | | | |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Leeding Density: gm/cc Variable Storege: Method Dry | | | | | |
| Blast (Relativo to THT): | Hazard Class (Quantity-Distance) Class 12 | | | | | |
| Air: Peak Pressure Impulse Energy | Compatibility Group D Exudation None | | | | | |
| Air, Confined: Impulse Under Weter: | Effect (* Temperature on Impact Sensiti ity (Chemically pure grade): (b) Temp. PA Impact Test C 2 Kg Wt, inches | | | | | |
| Peak Pressura Impulse Energy | 25 31 75 28 100 27 150 27 | | | | | |
| Underground: Peak Pressure Impulse Energy | 175 12 <u>Compatibility with Metals:</u> (a) In the presence of moisture, ammonium nitrate reacts with copper, iron steel, | | | | | |
| | brass, lead and cadmium. Entropy: (g) | | | | | |
| | cal/wolat 25 ⁰ 0 36.0 | | | | | |

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Ammonium Nitrate

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Solubility of ammonium nitrata, grams in 100 grams (%) of: (e)

| Wa | ter | Alc | ohol | Acet | le Acid | | Nitrie | Acid | Pyz | idine |
|---------------------------------|----------------------------------------------------|----------------------|-------------------------|----------------------------------------------|--------------------|-----------------------------------|----------------------------|-------------------------------------------------------------------------------------|----------|---------|
| 000 000 000 000 000 | <u>*</u> 113 192 297 421 580 871 | 8858 <mark>70</mark> | 2.5 5 7.5 10.5 | °c 16.6 27.0 80.9 101.0 120.0 | 5.8 20.7 125 | ° <u>c</u> 0 15 30 75 | 45.1 73.0 106 201 | ½ Nitric Acia 30.0 21.7 20.8 31.6 | °C 25 | ~ 20-25 |

Preparation:

Amonium nitrate is prepared by the neutralization of an aqueous solution of ammonia with nitric acid 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 Ohlsson and Norrbin for a composite dynamite.

Destruction by Chemical Decomposition:

Ammonium nitrate is decomposed by strong alkalies with the liberation of ammonia, and by sulfuric acid with the formation of ammonium sulfate and hitric acid.

References: 3

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

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

(c) D. P. MacDougall, 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>, <u>Part III - Miscellaneous</u> Sensitivity Tests; <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. Finkelstein and G. Gamow, Theory of the Detonation Process, NAVORD Report No. 90-46, 20 April 1947.

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

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

³See footnote 1, page 10.

Ammonium Nitrate

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| (1) | Also che | the follow | ing Picati | inny Arsen | al Techni | Ical Repor | rts on Am | nonium Ni | tr. te: |
|-----------------------------------|----------------------------------------------------|---------------------|-----------------------------|--------------------------------------------|-----------------------------------------------------|------------------------------------------|-----------------------------|-----------------------------------|---------------------|
| <u>0</u> | 1 | 2 | 3 | <u>4</u> | ٤ | <u>6</u> | I | 8 | 2 |
| 240 350 630 1290 1720 | 681 731 1051 1241 1311 1391 1431 | 182 1302 1682 | 743 1323 1783 2183 | 364 984 1094 1214 1234 1304 | 695 1145 1225 1455 1635 1675 1725 | 596 666 676 946 1106 1696 | 907 1117 1947 2167 | 548 638 938 1008 1038 | 799 1369 1409 |

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Ammonium Perchlorate

| Composition: | Molecular Weight: (ClH4NO4) 117.5 |
|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|
| C1 30.2 | Oxygen Belence: CO ₄ % +27.3 CO % +27.3 |
| N 11.9 NH _L ClOL | Density: gm/cc 1.95 |
| н 3.4 7 | Metting Point: "C |
| 0 54+5 C/H Ratio | Freezing Point: "C |
| | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 67 Sample Wt 20 mg | Boiling Yoint: *C Refractive Index, ng |
| Picatinny Arsenal Apparatus, in. 24 Sample Wt, rr g 24 | ng |
| Friction Pendulum Test: | Vocuum Stability Test: |
| Steel Shoe Snaps Fiber Shoe Unaffected | cc/40 Hrs, ct 90°C |
| Rifle Builet Impact Test: Trials | 100°C 0.13 120°C 0.20 |
| % Explosions | 135°C 150°C 0.32 |
| Partials Burned | 200 Gran Bomb Sa., "est: |
| Unaffected | Sand, gm 6.0 |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate |
| 5 435 | Lead Azide 0.20 |
| 10 | Tetryl 0,25 |
| 15 20 | Bailistic Mortar, % TNT: |
| | Trouzi Test, % TNT: |
| 73°C International Hast Test: % Loss in 48 Hrs | Plate Dent Test: Method |
| 100°C Heet " and: | Condition |
| % Loss, 1st 48 Hrs 0.02 | Confined |
| % Loss, 2nd 48 Hrs 0.00 | Density, gm/cc |
| Explosion in 100 Hrs None | Brisovice, % TNT |
| Flommability Index: | Detention Rate: Confinement |
| Hygroscopicity: % | Condition Charge Dismeter, in. |
| Veletility: | Density, gm/cr. Rate, meters/second |

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| | Ammonium Perchlorate | AMCP 706-177 |
|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|
| regmentation Test: | Shaped Charge Effectioness, TNT = P | 00: |
| 90 mm HE, M71 Projectile, I.et WC-91; Density, gm/cc Charge Wt, Ib | ³¹ ass Cones — Steel C Hole Volume Hole Depth | lones |
| Total No. of Fragments: For TNT | Colorless | |
| For Subject HE 3 Inch HE, M42A1 Projectilo, Let KC-5: Density, gm/cc Charge Wt, Ib | Principel Uses: Explosive ingredie mixtures used in pyrotechnic as projectile filler | |
| Total No. of Fragments; For TNT For Subject HE | Method of Londing: Pressed or can on composition of mixture | st depending |
| ragment Valacity: ft/sec At 9 ft | Looding Density: gm/cc Va | riable |
| At 25½ ft Density, gm/cc | Storage: | _ |
| inst (Relative to TNT): | | Dry Class 9 |
| Air: Peak Pressure Impulse Energy | Compatibility Group | None |
| Air, Confined: Impulse | Solubility in Water gm/100 cc saturated solution: | |
| Under Wethr: Peak Pressure Impulse Energy | 0°C 12 25°C 20 60°C 39 100°C 88 Preparation: | |
| Underground: Poak Pressure Impulse Energy | The perchlorates are prepared of the acid on a suitable base mal decomposition of certain ch by the electrolysis of chlorate | ; by the ther- hlorates; and |
| | Heat of: | <i>(</i> /- |
| | Formation, cal/gm | 665 |
| | | |

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Ammonium Perchlorate

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Origin: (c)

E. Mitscherlich first prepared, in 1832, crystals of annonium perchlorate from barium perchlorate and ammonium sulfate (Pogg Ann 25, 300). T. Schlosing treated a hot solution of sodium perchlorate with ammonium chloride, and on cooling, crystals of ammonium perchlorate were obtained (Comp rend, 73, 1269, [1871]). U. Alvisi treated a mixture of 76 parts of ammonium nitrate with 213 parts of sodium perchlorate, and obtained a grop of small crystals of ammonium perchlorate which were purified by recrystallization from hot water (German Patent, 103,993, 1898). A. Miolati mixed magnesium or calcium perchlorate with ammonium chloride and crystals of ammonium perchlorate deposited from the solution of very soluble magnesium or calcium chloride (German Patent, 112, 682, 1899).

References: 4

(a) W. R. Tomlinson, Jr., <u>Physical and Explosive Properties of Military Explosives</u>, PATR No. 1372, 29 November 1943.

(b) T. L. Davis, The Chemistry of Powder and Explosives, John Wiley and Sons, Inc., New York, 1943.

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

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

| 0 | <u>1</u> | 3 | 4 | 2 | <u>6</u> | 2 |
|-----|----------|-------------|-------------------|----------------------|----------|--------------|
| 100 | 321 | 843 1783 | 354 604 854 | 1095 1725 2205 | 1726 | 1049 1969 |

⁴See footnote 1, page 10.

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| Composition: | Malscular Weight: | 125 | |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------|------------|--|
| Nerium nitrate 67 | Oxygen Belence: CO, % CO % | -3 +13 | |
| 1NT 33 | Density: gm/cc Cast | 2.55 | |
| | Molting Point: *C | | |
| C/H Retio | Freezing Point: "C | ······· | |
| Impect Sensitivity, 2 Kg We: Bureau of Mines Apparatus, cm 35 | Boiling Point: *C | | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 11 Sample Wt, mg 24 | Refractive Index, ng ng ng | | |
| Friction Pandulum Test: | Vocuum Stability Toot: | | |
| Steel Shoe Fiber Shoe | cc/40 Hrs, at 90°C | | |
| Rifle Bullet Impact Test: Trices | 100°C | | |
| 96 Explosions | 135°C | | |
| Partials | 150°C | | |
| Burned | 200 Grem Bamb Sand Tast: | | |
| Unaffected | Sand, grn | 26.8 | |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 | Sensitivity to Initiation: Minimum Detonating Charge, s Mercury Fulminate | jm | |
| 5 Ignites 385 | Leod Azide | 0.20 | |
| 10 | Tetryl | 0.10 | |
| 15 20 | Ballistic Mortur, % TNT: | | |
| | Trauzi Test, % TNT: | | |
| 75°C International Heat Test: % Loss in 48 Hrs | Plote Dent Test: (s) Method | 73/27 B | |
| 100°C Heat Test: | Condition | Cast | |
| % Lous, 1st 48 Hirs | Confined | No | |
| % Loss, 2nd 48 Hrs | Density, gm/cc Brisance, % TNT | 2.52 61 | |
| Explosion in 109 Hzs | | | |
| Flummability Index: | Confinement | | |
| Hygroscopicity: % | Condition Charge Diameter, in. | | |
| <u>30°0, 97% RH</u> 0.00 | Density, gm/cc | | |
| Volatility: | Rate, meters/second | | |

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Beretol

| Booster Sensitivity Test: Condition | Cast | Denomposition Equation: Oxygen, atoms/sec |
|--------------------------------------------|---------------------------------------|---------------------------------------------------|
| | | (Z/sec) |
| Tetryl, gm | 100 | Heat, kilocolorie/male |
| Wax, In. for 30% Detonation | 0.32 | (ΔH, kcal/mol) |
| Wax, gm | | Temperature Range, *C |
| Density, gm/cc | 2.55 | Phose |
| Heat of: Combustion, cal/gm | | Annor Place Impact Test: |
| Explosion, cal/gm | | 60 mm Mortor Projectile: |
| Gas Volume, cc/gm | | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | | Aluminum Fineneus |
| Fusion, col/gm '73/25 Beratel | 2.8 (d) | |
| | | 500-th General Purpuse Bemba: |
| Specific Heat: coi/gm/*C (d) 75/2 | 5 BBEALS! | Plate Thickness, inches |
| | | |
| | | 1 ··· 1 |
| 0 0.147 85 0.21 | | 114 |
| 25 0.180 90 0.20 50 0.229 100 0.17 | | 134 |
| | - | |
| Surning Rate: cm/sec | | |
| | | Bom's Brop Test: |
| Thermal Conductivity: cal/sec/cm/°C | | 17, 2000-16 Sami-Armor-Piercing Bamb vs Concrete: |
| Coefficient of Exponsion: | | Max Sofe Drop, ft |
| Linear, %/*C | | 500-16 General Purpose Semb ve Concrete: |
| Volume, %/*C | | Height, ft |
| } | | Vriols |
| Hardness, Mahn' Scale: | | Unaffected |
| | | Low Order |
| Young's Modulus: | | High Order |
| E', dynes/cm* | | |
| E, Ib/Inch* | | 1000-Ib Governe Porpose Beach vs Concrete: |
| Density, gm/cc | | |
| · | · · · · · · · · · · · · · · · · · · · | Height, ft |
| Compressive Strength: Ib/inch ¹ | | Trials |
| | | Unaffected |
| Vapor Pressure: | | Low Order |
| *C mm Mercury | | High Onder |
| | | |
| | | |
| | | |

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AMCP 706-177 Baracol Flagmentation Test: Shaped Charge Effectiveness, TNT = 100: 90 mm HE, M71 Projectils, Lot WC-91: Glass Cones Steel Cones Density, gm/cc Hole Volume Hole Depth Charge Wt, Ib Total No. of Fragments: Color: For TNT For Subject HE Principal Uses: Bomb fill r 3 inch HE, M42A3 Projectile, Lor KC-5: Density, gm/cc Charge Wt, Ib Total No. of Fragments: **Muthod of Loading:** Cart For TNT For Subject HE Loading Density: gm/cc 2.55 Fragment Velocity: ft/sec At 9 ft At 251/2 ft Storage: Density, gm/cc Method Dry Class 9 Hazard Class (Quantity-Distance) **Blest (Relative to TNT):** Compatibility Group Group I Air: Peak Pressure Exudation Impulse Energy Preparation: Air, Confined: Impulse The appropriate weight of barium nitrate heated to about 90°C is added to moltor TNT Under Wuter: contained in a melting vessel equipped with Peak Pressure an agitator. Continue mixing until uniform, Impulse and load by pouring at the lowest practical temperature. Energy Origin: Underground: Peak Pressure Baratol, an explosive containing barium Impulse nitrate and TNT, the proportions varied to suit the required purposes, was developed Energy during World War I. \$

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AMCP 706-177

Baratol

References: 5

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

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

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

| <u>o</u> | 3 | <u>6</u> | <u>8</u> |
|--------------|--------------|----------|----------|
| 2010 2160 | 1783 2233 | 2226 | 21.38 |

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

See footnote 1, page 10.

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| Composition: % | Molecular Weight: | 111 | |
|------------------------------------------------------------------|------------------------------|-------------|--|
| Barium nitrate 50 | Oxygen Balance: CO: % | -24 | |
| TNT 35 | CO % | - 7 | |
| Aluminur 15 | Density: gm/cc | 2.32 | |
| | Melting Point: *C | | |
| C/H Ratio | Freezing Point: *C | | |
| Impact Sunsitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 30 | Boiling Point: *C | | |
| Sample Wt 20 mg | Refractive Index, no | | |
| Picatinny Arsenal Apparatus, In. 12 Sample Wt; mg 22 | n.0 | | |
| | ang n | | |
| Friction Pendulum Test: | Vecurim Stability Test: | | |
| Steel Shce | cc/40 Hrs, at | | |
| Fiber Shoe | 90°C | | |
| Rifie Bullet Impact Test: Triais | 100°C | | |
| 96 | 120°C | | |
| Explosions | 135°C 150°C | | |
| Partials | 150°C | | |
| Burned | 200 Gram Bomb Sand Test: | | |
| Unaffected | Sand, gm | 39.8 | |
| Explosion Temperature: *C | Sensitivity to Inivistion: | | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, | gm | |
|) 5 Ignites 345 | Mercury Fulminate | | |
| | Lead Azide | 0.20 | |
| 15 | Tetryl | 0.10 | |
| 20 | Bellistic Morter, % TNT: (a) | 96 | |
| | Trauxi Yest, % INT: | | |
| 75°C International Heat Test: % Loss in 48 Hrs | Piete Dent Test: | | |
| | Method Condition | | |
| 100°C Heat Test: | Confined | | |
| % Loss, 1st 48 Hrs | Density, gm/cc | | |
| % Loss, 2nd 48 Hrs | Brisance, % TNT | | |
| Explosion in 100 Hrs | | /h) | |
| Fiammability Indax: | Confinement | (b) None | |
| · · · · · · · · · · · · · · · · · · · | Condition | Cast | |
| Hygroscopicity: % | Charge Diameter, in. | 1.0 | |
| | Density, gm/cc | 2.32 | |
| | | | |

AMCP 706-177

Baronal

| Fregmentation Test: | Shaped 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: | Colorz |
| For TNT | Celor |
| For Subject HE | Principal Uses: Bomb filler |
| 3 inch HE, M42A1 Projectile, Let KC-5: | |
| Density, gm/cc | |
| Charge Wt, Ib | |
| Total No. of Fregments: | Method of Londing: Cast |
| For TNT | mende of Levelag: Cast |
| For Subject HE | |
| | Looding Density: gm/cc 232 |
| Fregment Velocity: ft/sec At 9 ft | |
| At 25% ft | Storage: |
| Density, gm/cc | |
| | Method Dry |
| Blast (Relativa to TNT): | Hozard Closs (Quantity-Disturce) Class 9 |
| Air: | Compatibility Group Group I |
| Peak Pressure | |
| Impulse | Exudation |
| Energy | |
| Air, Confined: | Preparation: |
| impuise | Procedure same as described under Baratol |
| | except aluminum is added to the barium ni- |
| Under Weter: Peak Pressure | trate-INT molton mixture under agitation until uniformity in comparison is obtained. |
| Impulse | |
| Energy | Booster Sensitivity Test: (c) |
| | Condition Cast |
| Underground: | Tetryl, gm 100 Wax, in. fcr 50% Detonation 0.86 |
| Peak Pressure | Density, gm/cc 2.32 |
| Impulse | |
| Energy | Heat of: |
| | Combustion, cal/gm 2099 |
| | Explosion, cal/gm 1135 |
| | Cas Volume, cc/gm 410 |
| | |
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References: 6

(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>, OSRD Report No. 5746, 27 December 1945.

(b) G. H. Messerly, The Rate 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.

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

(d) Arthur D. Little Report, <u>Study of Pure Explosive Compounds</u>, <u>Part III</u>, <u>Correlation of Composition of Mixture with Performance</u>, Contract No. DA-19-020-0RD-12, 1 May 1950.

(e) S. J. Lowell, Propagation of Detonation in Long and Narrow Columns of Explosives, PATR No. 2138, February 1955.

⁶See footnote 1, page 10.

Black Powder

| Composition: % | Maleculer Weight: 84 |
|----------------------------------------------------------------------------|--------------------------------------------|
| Potassium nitrate 74.0 | Oxygen Belencu: |
| Sulfur 10.4 | Nensity: jm/cc Variable |
| Charcoal 15.6 | Meking Point: "C |
| C/H Ratio | Freezing Point: "C |
| Impect Sensitivity, 2 Kg Wit: Bureau of Mines Apparatus, cm 32 | Bolling Point: "C |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in, 16 Sample Wt, mg 16 | Refrective Index, ក្រដ្ឋ កដ្ឋិ កដ្ឋិ |
| Friction Pondulum Test: | Vacuum Stability Test: |
| Steel Shoe Snap# | cc/40 Hrs, at |
| Fiber Shoe Unatfected | 90°C |
| Rifle Builet Import Test: Triais | |
| . % | 120°C 0.9 135°C |
| Explosions | 150°C |
| Partials | |
| Burned | 200 Gram Bomb Sand Test: |
| Unoffected | Sand, ym 8 |
| Explosion Temperatury: *C | Sensitivity to Initiation: |
| Seconds, 0.1 (no cap used) 510 | Minimum Detonating Charge, gm |
| 1 490 5 Tenites 427 | Mercury Fulminate |
| | Lead Azide |
| 10 356 15 | Sensitive to igniting fuse |
| 20 | Ballistic Mortar, % TNT: 50 |
| AV | Trouzi Yest, % TNT: (a) 10 |
| 75°C International Heat Test: | Plate Bent Test: |
| % Loss in 48 Hrs 0.31 | Method |
| 100°C Heet Test: | Condition |
| % Loss, ist 48 Hrs | Confined |
| % Loss, 2nd 48 Hrs | Density, gm/cc |
| Explosion in 100 Hrs | Brisance, % TNT |
| | Detenstion Rete: |
| Flammability Index: | Confinement |
| Hygroscopicity: % 25°C, 75% RH 0.75 | Condition |
| Hygroscopicity: % 25°C, 50% RH 1.91 30°C, 90% RH 2.51 | Charge Diameter, in. |
| Veletility: | Density, gm/cc 1.6 |
| · · · · · · · · · · · · · · · · · · · | Rate, meters/second 400 |

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Black Powder

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| Fregmentation Test: | Shered Charge Effectiveness, $TNT = 100$: |
|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91; Density, gm/cc Charge Wt, Ib | Glass Cones Steel Cones Hale Volume Hale Depth |
| Total No. of Fregments: For TNT | Color: Black |
| For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib | Principel Uses: 1. Igniter powder 2. Time rings (fuzes) |
| Tetel No. of Fregments: For TNT For Subject HE | Method of Loosing: 1. Loose (granulated) 2. Pressed |
| Fregment Velocity: ft/sec | Looding Density: gm/cc psi x 10 ³ 25 50 60 65 70 75 1.74 1.84 1.86 1.87 1.88 1.89 |
| 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 Impulse | Compatibility Group Group O Exudation None |
| Energy | 10000 Vanuum Stablelikar mont |
| Air, Confined: impulse | 100°C Vacuum Stability Test, cc gas/40 hrs: Initial Value 0.5 After 2 hours at 65°C 0.86 |
| Under Weter: Peak Pressure | After 2 hours at 65°C, 75% RH 1.46 Sensitivity to Electrostatic |
| impulse Energy | Discharge, Joules: (b) Unconfined >12.5 Confined 0.8 |
| Underground: Peak Pressure | Compatibility with Metals: |
| impulse Energy | Dry - Compatible with all metals when moisture content is less than 0.20%. |
| Initiating Efficiency: | Wet - Attacks all common metals except stainless steel. |
| Grams Required to Initiate | Heat of: |
| Igniter Comp K-31 2.0 Igniter Comp K-29 2.3 | Explosion, cal/gm 684 Gas Volume, cc/gm 271 |

Black Powder

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Preparation:

Willow or alder charcoal, flour or sulphur and 2-3% of water are placed in a tumbling barrel and mixed for a short pariod (about 1/2 hour). The mixture is transferred to a "wheel mill" and crystalline potassium nitrate containing 3-4% moisture is added and the mixture is incorporated 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 sluminum 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°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. Material finer than $\frac{440}{2}$ 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 at ribute 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 remained 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

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

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

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

See footnote 1, page 10.

| | | | | Bla | ck Powder | | | | AMCP 706-177 |
|-----------------------------------|---------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------|
| <u>0</u> | 1 | 2 | <u>3</u> | 4 | 2 | <u>6</u> | <u>7</u> | <u>8</u> | 2 |
| 250 710 850 1010 1450 | 91 471 661 901 1111 1241 1541 1541 1711 1911 2051 | 222 272 322 472 492 582 762 872 1622 1622 1712 1802 1912 | 163 363 453 843 1053 1243 1333 1493 1543 1493 1643 1843 1843 | 354 554 554 574 654 654 654 864 1154 1254 1504 | 65 415 545 605 1145 1275 1815 1885 1905 1915 | 56 176 356 686 746 1256 1316 1536 1576 1586 1946 | 347 407 437 547 547 1097 1737 1807 1827 | 188 318 428 558 608 (18 (98 838 1068 1388 1528 1778 1808 1838 1928 2178 | 379 819 839 849 859 1259 1309 1339 1349 1589 1739 1869 1889 |

1,2,4-Butanetriol Trinitrate (BITN) Liqu.d

| Composition: % | ****_********************** ****** | Molecular Weight: (C4H7N309) | 241 | |
|---------------------------------------------------------------|-------------------------------------------|----------------------------------|-----------|--|
| C 19.9 | | Oxygen Balance: | | |
| н 2.9 Н2С-ОНО2 | | CO, % CO % | -17 10 | |
| и 17.5 нс-ою2 | | Density: gm/cc Liquid | 1.52 | |
| 0 59.7 | | Melting Point: 'C | | |
| C/H Ratio 0.13 | | Freezing Point: "C | | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 58 | Boiling Point: *C | | |
| Sample Wt 20 mg | - | Refrective Index, no | 1.4738 | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | ≪1 # | n25 n25 | | |
| Friction Pandulum Test: | | Vecuum Stubility Test: | | |
| Steel Shoe | | cc/40 Hrs, at 90°C | | |
| Fiber Shoe | | 100*C | 2.33 | |
| Rifle Bullet Impact Tust: Trials | | 120°C | - •• | |
| % Explosions | | 135°C | | |
| Partiais | | 150°C | | |
| Burned. | | 200 Gram Bomb Sand Test: | | |
| Unaffected | | Sand, gm | 48.6 | |
| Explosion Temperature: 'C | | Sensitivity to Initiation: | | |
| Seconds, 0.1 (no cap used) | • | Minimum Detonating Charge, gm | | |
| i 5 Decomposes 230 | | Mercury Fulminate | | |
| 10 | t | | 0.20 | |
| 15 | | Tetryl | 0.10 | |
| 20 | | Ballistic Mortor, % TNT: | | |
| | | Trougi Test, % TNT: | | |
| 73°C International Heat Test: % Loss in 48 Hrs | | Plate Dent Test: | | |
| | | Method Condition | | |
| 100°C Heat Test: | | Contined | | |
| % Loss, 13t 48 Hrs | 1.5 | Density, gm/cc | | |
| % Loss, 2nd 48 Hrs | 1.2 | Brisance, 15 TNT | | |
| Explosion in 100 Hrs | None | | | |
| Flammability Index: | · · · · · · · · · · · · · · · · · · · | Detensition Roto: Confinement | | |
| | | Condition | | |
| Hygroscopicity: % (a) | | Charge Dlameter, in. | | |
| 100°F, 95% RH, 24 hrs | 0.14 | Density, gm/cc | | |
| Volatility: 60°C, mg/cm ² /hr | 46 | Rote, maters/second | | |

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1,2,4-Butanetriol Trinitrate (BTTN) Liquid

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| Fregmentation Test: 90mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, Ib | | Shaped Charge Effectiveness, TNT = 100; | | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|---------------------------------------------------------------------------------|----------------------|--|--|--|
| | | Giass Cones Steel Cones Hole Volume Hole Depth | | | | |
| Total No. of Fragments: For TNT | | Color: Yello | ow oil | | | |
| For Subject HE 3 inch HE, M42A1 Projectilo, Lot KC-5: Density, gm/cc Charge Wt, Ib Total No. of Fragmonts: For TNT For Subject HE | | Principel Uses: Explosive plasticizer for nitrocellulose | | | | |
| | | Method of Londing: | | | | |
| | | Loading Density: gm/cc | 1.72 | | | |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | | Sterege: Method | | | | |
| Blast (Relative to TNT); | | Hozard Class (Quantity-Distan | ce) | | | |
| Air: Peak Pressure Impulse Energy | | Compatibility Group Exudation | | | | |
| Air, Confined: Impulse | | Solubility in Water, gm/100 gm, at: 20°C 60°C | (*) 0.08 | | | |
| Under Water: Peak Pressure Impulse Energy | | Solubility of Water in, gm/100 gm; Solubility, gm/100 gm, at 25°C, in; | 0.)5 (a) 0.04 | | | |
| Underground: Peak Pressure Impulse Energy | | Ether Alcohol 2:1 Ether:Alcohol Acetone | - | | | |
| Heat of: Combustion, cal/gm Explosion, csl/gm Gas Volume, cc/gm | (a) 2168 1457 840 | Viscosity, centipolses: Temp, 25 ⁰ C | (a) 59 | | | |

1,2,4-Butanetriol Trinitrate (BTTN) Liquid

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Preparation (Inboratory Procedure):

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To a cooled mixture of 73.8 gm of 100% nitric acid, 46.2 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 $0^{\circ}-5^{\circ}$ C. When the agitation was completed, stirring was continued for one and one-helf hours. The mixture was poured into ice water, and the resulting oil suspension was extracted with three 100 mililiter portions of ether. The combined ether extracts were washed with water, then with a 5% sodium bicarbonate solution and finally with water. The neutralized extract was dried with anhydrous calcium chloride and then the ether was evaporated. The yellow oil was dried in a vacuum desiccator over anhydrous calcium chloride until the material was brought to constant weight.

Origin;

1,2,4-butanetical was first synthesized by Wagner and Ginsberg in 1894 by oxidizing allyl carbinol with potatisium permanganate 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 butanetrical (U. S. Rubber Company Quarterly Report, May 1948). Working with pure 1,2,4-butanetrical prepared by an improved technique of the Wagner method, the U. S. Naval Laboratory in 1948 nitrated the butanetrical on a laboratory and a pilot plant scale (Reference a).

References: 8

(a) J. A. Gallaghan, F. Macri, J. Bednarik, and F. McCollum, The Synthesis of 1,2,4-Butanetriol and the Evaluation of Its Trinitrate, U. S. Naval Powder Factory Technical Report No. 19, 10 September 1948.

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

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⁸See footnote 1, page 10.

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Composition A-3

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| Composition: % | | Malecular Weight: | | 227 | |
|---------------------------------------------------------------|------|----------------------------------|-------------|-----------------|--|
| RDX 91 | i | Oxygen Balance; CO: % CO % | | -48 -23 | |
| Wax 9 | | Density: gm/cc 12, | 000 psi | 1.65 | |
| Yangy. | | Melting Point: *C | | | |
| C/H Ratio | | Freezing Point: *C | | | |
| impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 100+ | Boiling Point: *C | | | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. | 16 | Refrective Index, nº, nº | | | |
| Sample Wt, mg | 17 | n ^o | | | |
| Friction Pendulum Test: | | Vacuum Stability Test: | | | |
| Steel Shoe Unaffe Fiber Shoe Unaffe | | cc/40 Hrs, at 90°C | | | |
| | | 100°C | | 0.3 | |
| Rifie Builet Impact Vest: Triols | | 120°C | | 0.6 | |
| % | | 135°C | | | |
| Explosions 0 | | 150°C | | | |
| Partials 0 | | | | | |
| Burned O | | 200 Gram Bomb Sand Test: | | | |
| Unoffected 100 | | Sand, gm | | 51.5 | |
| Explosion Temperature: *C | | Sensitivity to Initiation: | _ | | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating | | | |
| l 5 Decomposes 250 | ۲. | Mercury Fulminate | 2 | 0.22* | |
| • 10 | | Leod Azide | | 0.25* | |
| 15 | | * Alternative initi | ating charg | 68 | |
| 20 | | Ballistic Morter, % TN | | 135 | |
| •• | | Trauxi Test, % TNT: | | | |
| 75°C International Heat Test: % Loss in 48 Hrs | | Plate Dent Test: | (b) | | |
| | | Method | в | B | |
| 100°C Heat Test: | | Condition | Pressed | Pressed | |
| % Loss, 1st 48 Hrs | 0.15 | Confined | No | No | |
| % Loss, 2rid 48 Hrs | 0.15 | Density, gm/cc | 1.61 | 1.20 | |
| Explosion in 100 Hrs | None | Brisance, % TNT [*] | 126 | 75 | |
| Flammability Index: | 195 | Detenation Rate: Confinement | (c) | None | |
| | ►77 | Condition | | None Pressed | |
| Hygroscopicity: % 30°C, 90% RH | 0.0 | Charge Diameter, in. | | 1.0 | |
| | | Density, gm/cc | | 1.59 | |
| Volstility: 50°C, 15 days | 0.03 | Rate, meters/second | | 8100 | |

Composition A-3

| Fragmentation Test: | | Shaped Charge Effoctiveness, TNT == 100: |
|------------------------------------|----------------------------------------|------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot W | C-91: | Glass Cones Steel Cones |
| Density, gm/cc | 1.62 | Hole Volume |
| Charge Wt, Ib | 2.102 | Hole Depth |
| Total No. of Fragments: | | Celer: White-buff |
| For TNT | 703 | |
| For Subject HE | 1138 | Principal Uses: HE, SAP, AP projectiles; |
| 3 inch HE, M42A1 Projectile, Lot i | (C-3: | Shaped Charges |
| Density, gm/cc | 1.64 | |
| Charge Wt, Ib | 0.861 | |
| Totel No. of Fragmants: | | Method of Le ing: Preased |
| For TNT | 514 | |
| For Subject HE | 0L7 | Leading Density: gm/cc psi x 10 ³ |
| | | |
| Fragment Velocity: ft/sec | | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ |
| At 9 ft | 2800 | Storage: |
| At 251/2 ft | 2530 1.61 | a an |
| Density, gm/cc | 1.01 | Method Day |
| Blast (Relative to TNT); | ······································ | Hoxard Class (Quantity-Distance) Class 9 |
| Ain | | Compatibility Group Group I |
| Peak Pressure | | |
| Impulse | | Exudation Does not exude at 65°C when waxes melting sharply at or above 75°C are used. |
| Energy | | |
| | | Preparation: |
| Air, Confined: Impulse | | A water slurry of RDX is heated to 100°C |
| Impaine | | with agitation. Wax and a wetting agent are |
| Under Water: | | added and the mixture, under agitation, is cooled below the molting 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 Rate of Detonation: (e) |
| Underground: | | 16 hrs st, °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 50% Detonation 1.70 Density, gm/cc 1.62 |
| | | |
| | | Heat of: Combustion, cal/gm 1210 |

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Composition A-3

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Compatibility with metals:

Dry - Aluminum, stainless sieel, 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:

Developed by the British during World War II as RDX and beeswax. Subsequent changes in the United States replaced beeswax with synthetic waxes, 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, <u>Physical Testing of Explosives</u>, Part III - Miscellaneous <u>Sensitivity Tests</u>; <u>Performance Tests</u>, OSRD Report No. 5746, 27 December 1945.

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

(c) G. H. Messelly, The Rate 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.

(d) L. C. Smith and S. R. Walton, <u>A Consideration of K.K/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 Rates of the More Important Military Explosives at Several Different Temperatures, FATE No. 2383, November 1956.

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

| <u>o</u> | 1 | 2 | 3 | <u>4</u> | ٤ | <u>6</u> | Ĩ | <u>8</u> | 2 |
|--------------|--------------|--------------|------|------------------------------|----------------------------------------------|--------------|----------------------|------------------------------|--------------|
| 1380 1910 | 1451 1761 | 1492 2112 | 1493 | 1424 1614 1634 2154 | 1325 1585 1595 1715 1885 2235 | 1556 1936 | 1687 1787 1797 | 1338 1388 1728 1838 | 1639 2179 |

⁹See footnote 1, page 10.

| emposition: % | | Molecular Weight: | | 224 |
|---------------------------------------------------------------------------|--------------|-----------------------------------|----------|-----------|
| - | | Oxygan Bulance: | | |
| rdx 60 | | CO, % CO % | | -43 10 |
| INT 40 | | | | |
| Wax, added 1 | | | | 1.65 |
| | | Melting Point: *C | (1) | 78-80 |
| C/H Ratio | | Freezing Point: *C | | |
| mpact Sansitivity, 2 Kg We: | | Boiling Point: *C | | |
| Bureau of Mines Apparatus, cm Sample V/t 20 mg | | Refrective Index, no | | |
| Picutinny Arsenal Apparatus, in. | 14 19 | n | | |
| Sample Wt, mg | 17 | n <mark>e</mark> | | |
| riction Pendulum Test: | | Vecuum Stebility Test: | | |
| Steel Shoe Unaffected | | cc/40 Hrs, ut | | |
| Fiber Shoe Unaffected | | 90°C | | • - |
| tifle Bullet Impect Test: Trials | | | | 0.7 |
| Anne Beller Impect Fest: Fridis . % | | 120°C | | 0.9 |
| Explosions 3 | | 135°C | | |
| Partials 13 | | 150°C | | 11+ |
| Burned 4 | | 200 Grem Bomb Sand Test: | _ | |
| Unaffected 80 | | Sand, gm | | 54.0 |
| Explosion Temperatury: *C | | Sensitivity to Initiation: | | |
| Second., 0.1 (no cap used) 526 | | Minimum Detonating Ch | orge, gm | |
| 1 368 5 Decomposes 278 | | Mercury Fulminate | | 0.22* |
| 10 255 | | Lead Azide | | 0.20* |
| 15 > 250 | | Terryl * Alternative initist | ing cha | rges |
| 20 = 250 | | Ballistic Morter, % TNT: | (a) | 133 |
| | _ | Treuxi Test, % TNT: | (b) | 130 |
| 'C International Heat Test: % Loss in 48 Hrs | | Plate Dent Test: | (c) | |
| | | Method | | B |
| 00°C Heat Test: | | Condition | | Cast |
| % Loss, 1st 48 Hrs | 0.2 | Confined | | No |
| % Loss, 2nd 48 Hrs | 0.2 | Density, gm/cc Brisonce, % TNT | | 1.71 |
| Explosion in 100 Hrs | None | | | 132 |
| lammability Index; | 177 | Detension Rete: Confinement | | None |
| | | Condition | | Cast |
| iygroscopicity: % 30⁰C, 90% RH | 0.02 | Charge Diameter, in. | | 1.0 |
| | | Density, gm/cc | | 1.68 |
| foletility: | | | | 7840 |

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Compost tion B

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Composition B

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| Beester Sensitivity Tast: | (a) | Decomposition Equation: | | |
|-----------------------------------------------|---------------------------------------|------------------------------|-------------|-----------------|
| Condition | Cast | Oxygen, atoms/sec (Z/scc) | | |
| Tetryi, gm | 100 | Heat, kilocalorie/mole | | |
| Wax, in. far 50% Detonation | 1.40 | (JH, kcal/mol) | _ | |
| Wax, gm | | Temperature Range, *C | 2 | |
| Density, gm/cc | 1.69 | Phase | | |
| Heat of: | (e) 2790 | Armer Plate Impact Test: | | (e) |
| Combustion, cal/gm | 1240 | | | ·.· |
| Explosion, cal/gm | 1240 | 60 mm Martar Projecti | | |
| Gas Volume, cc/gm | | 50% Inert, Velocity, | , ft/sec | 209 |
| Formation, cal/gm | | Aluminum Fineness | | |
| Fusion, cal/gm (1) | 8.0 | 500-ib General Purpose | Bombs: | |
| Specific Hest: col/gm/*C (1) | | | | |
| <u>°C</u> | | Plate Thickness, incl | | |
| | 0. 376 | | Trials | % Inert |
| -75 0.235 75 0 0.220 85 | 0.376 0.354 | 1 | 4 | 100 |
| 25 0.254 90 | 0.341 | 14 | 6 | 50 |
| 50 0.305 100 | 0.312 | 116 | 2 | 0 |
| | | 181 | 0 | |
| Burning Rate: cm/sec | | Bomb Drap Test: | | |
| Thermal Conductivity: cal/sec/cm/°C | | T7, 2000-lb Semi-Armo | or-Piercing | lomb vs Concret |
| Coefficient of Expansion: | · · · · · · · · · · · · · · · · · · · | Max Safe Drop, ft | | |
| Linear, %/*C | | 500-16 General Purpos | e Bomb ve (| Concrete: |
| N. 1. 01.10 m | | | No Seal. | See 1 |
| Volume, %/*C | | Height, ft | 4000 | 4000 |
| Hardness, Mohs' Scalo: | | Trials | 65 | 39 |
| riereness, mens Scele: | | Unoffected | 58 | 36 |
| Young's Modulus: | | Low Order | 2 | 2 |
| E', dynes/cm ² | | High Order | 5 | 1 |
| E, ib/inch ² | | | | _ |
| Density, gm/cc | | 1050-15 General Purpo | ee Bomb vs | Concreto: |
| wanany, gm/ce | | | | |
| Compressive Strength: Ib/inch ² (b |) 1610-2580 | Trials | | |
| Density, gm/cc | 1.68 | Unoffected | | |
| | | Low Order | | |
| Voper Pressure: *C mm Mercury | | | | |
| | 7 | High Order | | |
| | | | | |
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Composition B

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| Fragmentation Test: | | Shaped Charge Effectiveness, TNT = 100: | | | |
|------------------------------------|-------|--------------------------------------------------------------------|--|--|--|
| 00 mm ME M71 Pastantia tat M6 | ° 61. | (g) (h) Glass Cones - Steel Cones | | | |
| 90 mm HE, M71 Projectile, Lot WC | | Hole Volume 178 162 | | | |
| Density, gm/cc | 1.65 | | | | |
| Charge Wt, Ib | 2.187 | Hole Depth 125 148 | | | |
| Total No. of Fragments: | | Celor: Yellow-brown | | | |
| For TNT . | 703 | Terton-prom | | | |
| For Subject HE | 998 | Principel Uses: Fragmentation bombs, HE | | | |
| 3 inch HE, M42A1 Projectile, Lot K | C-5: | projectiles, grenades, shaped | | | |
| Density, gin/cc | 1.67 | charges | | | |
| Charge Wt, Ib | 0.882 | | | | |
| | | | | | |
| Total No. of Freyments: | | Method of Landing: Cast | | | |
| For TNT | 514 | weinog er Lenging: | | | |
| For Subject HE | 701 | | | | |
| | | Looding Density: gm/cc 1.68 | | | |
| Fragment Velocity: ft/sec | | - | | | |
| At 9 ft | 2940 | | | | |
| At 251/2 ft | 2680 | Storage: | | | |
| Density, gm/cc | 1.68 | | | | |
| | | Method Dry | | | |
| Blast (Relative to TNT): | (1) | Hazard Class (Quantity-Distance) Class 9 | | | |
| Air: | | Compatibility Group Group I | | | |
| Peok Pressure | 110 | | | | |
| Impulse | 110 | Exudation Very slight when stored at 71°C | | | |
| Energy | 116 | • | | | |
| • | | Origin: | | | |
| Air, Confined: | | | | | |
| Impulse | 75 | RDX Composition B was developed by the | | | |
| | | British between World War I and World War II. | | | |
| Under Weter: Peak Pressure | 110 | It was standardized by the United States early in World War II. | | | |
| | 108 | | | | |
| Impul se | | Effect of Temperature on | | | |
| Energy | 121 | Rate of Detonation: (1) | | | |
| Underground: | | 16 hrs at, °C -54 24 | | | |
| Prok Pressure | 104 | Density, gm/cc 1.69 1.69 | | | |
| Impulse | 97 | Rate, m/sec 7720 7660 | | | |
| Energy | ~ , | Bulk Modulus at Room (j) | | | |
| Crater radius cubed | 107 | <u>Temperature (25°-30°C);</u> | | | |
| | | % Wax in Comp B 1 2 3 | | | |
| | | $D_{vnes/cm^2} \times 10^{-10}$ 5.10 3.56 2.34 | | | |
| | | Density, gm/cc 1.72 1.70 1.68 | | | |
| | | Viscosity, poises: Temp, 83°C 3.1 | | | |
| | | Temp, 83°C 3.1 95°C 2.7 | | | |

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Composition B

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Compatibility with Metals:

Dry - Magnesium, sluminum, magnesium-sluminum 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 couted with acid-proof black paint and mild steel plated with cadmium, copper, nickel or zinc are slightly affected. Magnesium and magnesium-aluminum alloy are more heavily affected.

Preparation:

Water wet RDX is added slowly with stirring to molten TNT 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° C. While this is stirred vigorously, there is added 12 parts of a solution, heated to 70° C, of 1 part sodium sulfide (Na₂S'9H₂O) in 4 parts water. The sulfide solution is added slowly so that the temperature of the acetone solution does not rise above 60° C. After addition is complete, stirring is continued for one-half hour.

References: 10

(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>, OSRD Report No. 5746, 27 December 1945.

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

(c) D. P. MacDougell, 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) Committee of Divisions 2 and 8, NDRC, Report on HBX and Tritonal, USRD Report 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) Eastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Sec III, Variation of Cavity Effect with Explosive Composition, NDRC Contract W672-OND-5723.

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

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

¹⁰See footnote 1, page 10.

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Composition B

(j) W. S. Cramer, Bulk Compressibility Data on Several High Explosives, NAVORD Report No. 4380, 15 September 1955.

| (k) | Also sce | the following | ng Picati | inny Arsena | L Techn | ical Report | e on RD | (Composit | tiou B: |
|--------------------------------------|----------------------|----------------------|--------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------|------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------|
| <u>o</u> | <u>1</u> | 2 | 3 | <u>4</u> | ٤ | <u>6</u> | ĩ | <u>8</u> | 2 |
| 1360 1530 2100 2160 2190 | 1451 2131 2151 | 1402 1482 1592 | 1313 1433 1803 1983 2053 2063 2103 2233 | 1224 1424 1944 2004 2104 | 1325 1435 1585 1595 1865 1885 2055 2125 2155 2175 2235 | 1466 1476 1556 1756 1956 2236 | 1207 1437 1457 1737 1797 2007 2147 | 1338 1388 1438 1458 1688 1728 1828 1838 1978 2008 2138 2168 | 1339 1379 1469 1819 2019 |

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

Composition B, Desensitized

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| Composition: | <u>I*</u> | II** | Molecular Weight: | <u>I*</u> | 11** |
|---------------------------------------------------------------|---------------------------|---------------------------------------|------------------------------------|------------------------------|-------------|
| % | | | | ee Cyclonite | See Comp B |
| RDX TNT | 60 40 | 55.2 40.0 | Oxygen Balance: | | |
| Wax, added, (Stanolind | | -0.0 | E | ee Cyclonite ee Cyclonite | |
| or Ariatowax, 1650/ 1700F) | 5 | | CO 48 5 | ee Cyclonice | See Comp B |
| Vinylseal (MA28-14), added | 2 | | Density: gm/cc Cast | 165 | 1.65 |
| Vistanex (B120) Albacer Wax | | 1.2 3.6 | Melting Point: *C | | |
| C/H Ratio | | | Freezing Point: "C | | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cn | 1* 95 | <u>11**</u> | Boiling Point: *C | | |
| Sample Wt 20 mg | ל איי איי | | Refractive Index, no | | |
| Picatinny Arsenal Apparatus, i | n, 14 | 13 | | | |
| Sample Wt, mg | 17 | 16 | n ₃₁ | | |
| | · | | - n <mark>%</mark> | | |
| Friction Pendulum Test: | | | Vecuum Stebility Test: | <u>I*</u> | <u>11**</u> |
| | fected | | cc/40 Hrs, at | | |
| Fiber Shoe Unaf | fected | | 90°C | | |
| Rifle Bullet Impact Test: Tria | | | - 100°C | | |
| • • • • • | | **** | 120°C | 0.99 | 0.92 |
| g Explosions | , <u>1*</u> | <u>11**</u> 0 | 135*C | | |
| Partials | 0 | 0 | 150°C | 11+ | 11+ |
| Burned | 5 | 0 | | | |
| Unaffected | 95 | 100 | 200 Gram Bemb Sand Test | | <u>11**</u> |
| Undiffected | | | Sand, gm | 52.7 | 55.0 |
| | 'C <u>I*</u> | <u>II**</u> | Sensitivity to Initiation: | <u>I*</u> | <u>11**</u> |
| Seconds, 0.1 (no cap used) | | | Minimum Detonating Cl | narge, gm | |
| 1 5 Decomposes | 060 | 000 | Mercury Fulminate | | |
| * **** | 260 | 270 | Leod Azide | 0.22 | 0.26 |
| 10 | | | Tetryl | | |
| 15 20 | | | Baliistie Mustar, % TNT: | | |
| | | | T.aude Test, % TNT: | | |
| 75°C International Heat Test: % Loss in 48 Hrs | | | Plate Deni Test: | | |
| | | ···· | Method | | |
| 100°C Heat Test: | 1* | <u>II**</u> | Condition | | |
| % Loss, 1st 48 Hirs | 0.05 | 0.12 | Confined | | |
| % Loss, 2nd 48 Hrs | 0.19 | 0.18 | Density, gm/cc | | |
| Explosion in 100 Hrs | None | None | Brisonce, % TNT | | |
| Flemmability Index: | - <u></u> | · · · · · · · · · · · · · · · · · · · | Detenation Rate: Confinement | | |
| | | | | | |
| Hygroscopicity: % | - · · · · · · · · · · · · | | - Condition | | |
| 30°C, 90% RH | 0.00 | 0.00 | Charge Diameter, in. | | |
| | Nil | Nil | Density, gm/cc | | |
| Veletility: | | | | | |

*Desensitized Comp B, designated I, uses emulsified wax. **Desensitized Comp B, designated II, uses conted RDX.

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Composition B, Desensitized

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| Fragmentation Test: | | | Shaped Charge Effectiveness, TNT = 100: | | | |
|----------------------------------------------|---------------------|------------|-----------------------------------------|----------------------------------------|------------|--------------|
| 90 mm HE, M71 Prejectile, Density, gm/cc | Let WC-91; | | Hole Volum | Glass Con | es Steel (| Cones |
| Charge Wt, Ib | | | Hole Depth | | | |
| Total No. of Fregments: For TNT | | | Celer: | | Yellow- | prom |
| For Subject HE | | | Principal Uses | | Bomba | |
| 3 inch HE, M42A1 Projectile | , Let KC-S: | The second | | - | | |
| Density, gm/cc | 1.65 | 1.65 | 1 | | | |
| Charge Wt, Ib | 0.87 | 0.86 | | | | |
| Total No. of Freyments: | | | Method of Lo | adina. | Cast | |
| For TNT | 514 | 514 | | | | |
| For Subject HE | 609 | 659 | Leading Densi | ity: gm/cc | 1.65 | |
| Fregment Velocity: ft/sec | | | | | | |
| At 9 ft At 25½ ft | | | Storage: | ······································ | | |
| Density, gm/cc | | | Method | | | Dry |
| Blast (Relative to TNT); | | | Hozard Cla | ss (Quantity- | Distance) | Class 9 |
| Air: Peak Pressure | | | Computibili | ty Group | | Group I |
| Impulse | | | Exudation | | | |
| Energy | | | · · | | | · |
| Air, Confined | | | Viscosity, | | <u>1*</u> | <u>11**</u> |
| Impulse | | | Temp, 83 | | 3.5 2.6 | 3.1 2.7 |
| Under Water: Peak Prossure | | | References | <u>.</u> | | |
| Impulse | | | (a) See | the follo | wing Picat | inny Arsenal |
| Energy | | | Technical Desensitize | Reports on | RDX Compo | sition B, |
| Underground: Peak Pressure | | | 1 | 3 | ٤ | 6 |
| Impulse | | | 2.01 | 1313 | 1435 | 1,56 |
| Energy | • | | | 2053 | 1865 | -175 |
| *Desensitized Comp B, des emulsified wax. | ignated I, | uses | | | | |
| **Desensitized Comp B, des coated RDX. | lignated I <u>I</u> | , uses | | | | |
| | • | | 1 | | | |

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Composition C

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| Composition: % | | Molecular Weight: | |
|---------------------------------------------------------------|--------------|--------------------------------------|-------------|
| RDX 88.3 | | Oxygen Belence: CO ₂ % | |
| Plasticizer, non- | | CO % | |
| explosive 11.7* | | Density: gm/cc | |
| *Nonexplosive oily plasticize: 0.6% lecithin. | r containing | , Meiting Paint: *C | |
| C/H Ratio | | Freezing Point: "C | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 100+ | Beiling Point: "C | |
| Sample Wt 20 mg | | Refrective Index, no | |
| Picatinny Arsenal Apparatus, in. | | 11 ² | |
| Sample Wt, mg | | ns | |
| | | п ₃₀ | |
| Friction Pendulum Test: Steel Shoe | | Vacuum Stubility Test: | |
| Steel Shoe Fiber Shoe | | cc/40 Hrs, at 90°C | |
| | | | 0.3 |
| Rifle Bullet Impact Test: Trials | | 120°C | 0.7 |
| % | | 135°C | 0.1 |
| Explosions 0 | | 150°C | |
| Partials 0 | | 150 C | |
| Burned 0 | | 200 Gram Somb Sand Test: | |
| Unaffected 100 | | Sand, gm | 46.5 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gr | n |
| 1 | | Mercury Fulminete | |
| 5 Decomposes 285 | | Lead Azide | 0.25 |
| 10 | | Tetryl | 0.11 |
| 15 | | Bellistic Mortor, % TNT: (5) | 120 |
| 20 | | Treuxi . set. % TNT: | 120 |
| 75°C International Heat Test: | | | |
| % Loss in 48 Hrs | | Plate Dant Test; | * |
| | | Method | A |
| 100°C Heat Test: | | 1 | and Tamped |
| 95 Loss, 1st 48 Hrs | 0.04 | Confined | Yes |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/cc | 1.58 112 |
| Explosion in 100 Hrs | None | Brisance, % TNT | 114 |
| Shammahilika Indone | · | - Detention Rate: | |
| Flammability Index: | | Confinement | |
| Hygrescopicity: % 30°C, 95% RH | 0.25 | - Condition | |
| nygrescepterty: 70 30-0, 90% RH | V.27 | Charge Diameter, in. | .' |
| Volatility: 25°C, 5 days | 0.00 | Density, gm/cc | |
| | | Rate, meters/second | |

Composition C

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| Frogmentation Test: | Sheped Charge Effectiveness, TNT = 100: | | | | |
|----------------------------------------|----------------------------------------------|--|--|--|--|
| | (f) (g) | | | | |
| 90 mm HE, M71 Projectile, Lot WC-91: | Glass Cones Steel Cones | | | | |
| Density, gm/cc | Hole Volume 113 114 | | | | |
| Charge Wt, Ib | Hole Depth 101 114 | | | | |
| Total No. of Fragments: | Celer: White | | | | |
| For TNT | | | | | |
| For Subject HE | Principel Uses: Plastic demolition explosive | | | | |
| 3 inch HE, M42A1 Projectile, Lot KC-5: | • | | | | |
| Density, gm/cc | | | | | |
| Charge Wt, Ib | | | | | |
| Total No. of Fragments: | | | | | |
| For TN1 | Method of Loading: Hand tamped | | | | |
| For Subject HE | | | | | |
| | Looding Density: gm/cc 1.49 | | | | |
| Fragment Velocity: ft/sec | | | | | |
| At 9 ft At 25½ ft | Storege: | | | | |
| Density, gm/cc | | | | | |
| Servery, girt co | Method Dry | | | | |
| Blact (Relative to TNT): | Hozard Class (Quontity-Distance) Class 9 | | | | |
| Air: | Compatibility Group Oroup I | | | | |
| Peak Pressure | | | | | |
| Impulse | Exudation Exudes above 40°C | | | | |
| Energy | | | | | |
| Air, Confined: | Plasticity: | | | | |
| Impulse | Below 0°C Brittle (0°C) | | | | |
| | 0-40°C Plastic | | | | |
| Under Weter: Peak Pressure | Above 40°C Exudes (40°C) | | | | |
| reak pressure Impulse | References: | | | | |
| Energy | See references for Composition C-4. | | | | |
| Underground: Peak Pressure | | | | | |
| Impulse | | | | | |
| Energy | | | | | |
| | | | | | |
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Composition C-2

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| Composition: | | Molecular Weight: | |
|---------------------------------------------------|----------------------------------------|--------------------------------------|----------------------------------------|
| % RDX 78.7 | | Oxygen Belence: | |
| TNT 5.0 | | CO: % | |
| DNT 12.0 | | CO % | |
| MNT 2.7 | | | ······································ |
| NC 0.6 | | Density: gm/cc | |
| Solvent 1.0 | | Melting Point: *C | |
| C/H Ratio | | Freesing Paint: *C | ······································ |
| Impact Sansitivity, 2 Kg Wt: | 90 | Boiling Point: "C | · · · · · · · · · · · · · · · · · · · |
| Bureau of Mines Apparatus, cm Sample Wt 20 ma | 90 | Refrective Index, no | |
| Picatinny Arsenal Apparatus, in. | | | |
| Sample Wt, mg | | n <u>2</u> | |
| | •••• | ng | |
| Friction Pendulum Test: | | Vecuum Stability Test: | ····· |
| Steel Shoe | | cc/40 Hrs, at | |
| Fiber Shoe | | 90°C | |
| | <u> </u> | 100°C | 2.0 |
| Rifle Builet Impact Test: Trials | | 120°C | 9.0 |
| ₩ | | 135°C | |
| Explosions 0 | | 150°C | |
| Partials 20 | | | |
| Burned 0 | | 200 Grem Bemb Sund Test: | |
| Unoffected 80 | | Sond, gm | 47.5 |
| Explusion Temperature: *C | | Sensitivity to Initiation: | <u></u> |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, g | aw . |
| 1 | | Mercury Fulminote | |
| 5 Decomposes 285 | | Lead Azide | 0.25 |
| 10 | | Tetryl | 0.10 |
| 15 | | | |
| 20 | | Bellistie Mortor, % TNT: (a) | 126 |
| TRACING AND | فسيريا الأذاريين فتقاذ سيريا الأقفارين | Trevel Test, % TNT: | ····· |
| 75°C International Heat Test: % Loss in 48 Hrs | | · Flate Dent Tast: (c) | |
| | | Method | В |
| 100°C Heat Test: | | Condition | Hand tamped |
| ' % Loss, 1st 46 Hrs | 1.8 | Confined | No |
| % Loss, 2nd 48 Hrs | 1.4 | Density, gm/cc | 1. 52 |
| | - | Brisance, % TNT | 111 |
| Explosion in 100 Hrs | None | | |
| Fig.nmability Index: | 178 | Detenction Rate: (d) Confinement | Vara |
| · · · · · · · · · · · · · · · · · · · | | | None |
| Hygrescepicity: % 30°C, 95% RH | 0.55 | Condition | Hand tamped |
| ulaineenhicula: 20 . 01 ADA Kr | 0.33 | Charge Diameter, in. | 1.0 |
| Veletility: 25°C, 5 days | 0.00 | Density, gm/cc | 1,57 |
| Veletility: 25°C, 5 days | | Rote, meters/second | 7660 |

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Composition C-2

| Fragmentation Test: | Shapod Charge Effectiveness, TNT = 100: | | | | |
|---------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, Ib | Glass Cones Steel Cones Hole Volume Hole Depth Celer: White Principel Uses: Plastic demolition explosive | | | | |
| Totel No. of Fregments: For TNT For Subject HE 3 Inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, ib | | | | | |
| Total No. of Fragments: For TNT For Subject HE Fragment Velocity: ft/sec | Method of Looding: Hand tamped Looding Density: ym/cc 1.57 | | | | |
| At 9 ft At 25½ ft Density, gm/cc | Storege: Method Day | | | | |
| Biest (Relative to TNT): Air: Peak Pressure Impuise Energy | Hazard Closs (Quantity-Distance) Class 9 Compatibility Group Group I Exudation Volstilizes above 52 ⁰ C | | | | |
| Air, Confined: Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse Energy | Plasticity: Below O ^O C Plastic (-30 ^O C) O.40 ^O C Plastic above 40 ^O C Hard (52 ^O C)* *Due to volitalization of plasticizer. <u>References:</u> See references for Composition C-4. | | | | |

Composition C-3

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| Composition: | | Molecular Weight: | | | |
|----------------------------------------------------------------------------------|---------------------------------------|------------------------------------------------------------------------------------------------|------------------|--|--|
| % RDX Tetryl TNT | 77 3 | Oxygen Belence: CO ₂ % CO % | | | |
| DNT MNT | 10 5 | Density: gm/sc | | | |
| NC | 5 | Melting Point: *C | | | |
| C/H Ratio | | Freezing Point: *C | | | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatu | | Boiling Point: *C | | | |
| Sample Wt 20 mg Picatinny Arsenal Appara Sample Wt, mg | | Refractive Index, nº nº nº | | | |
| Friction Pendulum Test: | | Vacuum Stability Test: | | | |
| Steel Shoe Fiber Shoe | Unsflected Unsflected | cc/40 Hrs, at 90°C | | | |
| Rifle Bullat Impoct Test: | Trials | 100°C 120°C | 1.21 11+ | | |
| Explosions | 9% O | 135°C 150°C | | | |
| Partials Burned Unaffected | 40 0 60 | 200 Gram Bomb Sand Test: Sand, gm | 53.1 | | |
| Explosion Temperature: 'C Seconds, 0.1 (no cap used) 1 5 Decomposes 280 | | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide | <i>)</i> .20 | | |
| וס 51 | | Tetryi | 0.08 | | |
| 20 | | Ballistic Morter, % TNT: (a) | 126 | | |
| | · · · · · · · · · · · · · · · · · · · | Trauxi Test, % TNT: (b) | 117 | | |
| 75°C International Heat Tes % Loss in 48 Hrs | *: | Plate Dent Test: (c) Method | В | | |
| 100°C Heat Test: | | | d 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 | Brisonce, % TNT | 118 | | |
| Flammability Index: | | Detenction Rate: (d) Confinument | None | | |
| Hygroscopicity: % 30°C, | 95% RH 2.4 | Charge Diameter, in. | id tamped 1.0 | | |
| Voletility: 25°C, | 5 days 1.15 | Density, gm/cc Rote, meters/second | 1.60 7625 | | |

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Composition C-3

| Frigmuntution Test: | | Shaped Charge Effectiveness, TNT = 100: | | | |
|---------------------------------|---------|-----------------------------------------|---------------|--|--|
| 90 mm HE, M71 Projectile, Lot | WC-91: | Gloss Cones Steel C | ones | | |
| Density, gm/cc | 158 | Hole Volume | | | |
| Charge Wt, Ib | 2045 | Hole Depth | | | |
| Total No. of Fragments: | | Color: Yellov | | | |
| For TNT | 703 | | | | |
| For Subject HE | 944 | Principai Usos: Plastic demoliti | on avalorive | | |
| 3 inch HE, M42A1 Projectile, La | H KC-5: | | ou extrustive | | |
| Density, gm/cc | 1.60 | | | | |
| Charge Wt, Ib | 0.842 | | | | |
| Total No. of Fragments; | | Method of Londing: Hand t | | | |
| For TNT | 514 | Marinos er Levelingt hand (| wabed | | |
| For Subject HE | 671 | | | | |
| | | Loading Density: gm/cc | 1.58 | | |
| regment Velocity: ft/sec | | | | | |
| At 9 ft At 25½ ft | | Sturage: | | | |
| Density, gm/cc | | | | | |
| | | Method | Dry | | |
| last (Relative to THT). | | Hazard Class (Quantity-Distance) | Class 9 | | |
| Ain | | Compatibility Group | Group I | | |
| Peak Pressure | 105 | | _ | | |
| Impulse | 109 | Exudation Exudes at 77°C | ; | | |
| Energy | | | • | | |
| Air, Confined: | | Plasticity: | | | |
| Impulse | | Below O ^o C Ha | ird (-29°C) | | |
| | | 0-40°C PI | astic | | |
| Under Water: Peak Pressure | ۰. | Above 40°C Eb | udes (77°C) | | |
| Impulse | | Booster Sensitivity Test: () | a) | | |
| Energy | | | | | |
| | | Condition Pr Tetryl, gm | '255ed 100 | | |
| Underground: | | Wax, in. for 50% Detonation | 1.36 | | |
| Peak Pressure | | Density, gm/cc | 1.62 | | |
| Impulse | | References: | | | |
| Energy | | | | | |
| | | See references for Composition | on C-4. | | |
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Composition C-4

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| Composition: % | | Maleculer Weight: | | | | | | | |
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| RDX | 91 | Oxygen Beience: CO ₂ % | _ | | | | | | |
| Plasticizer, non- explosive | 9# | CO % | | | | | | | |
| <pre>* Contains polyisobutylene 2.1%; motor oil. 1.6% and di(2-ethylhexyl) sebacate 5.3%. C/H Romo</pre> | | Density: gm/cc Melting Point: "C Freezing Point: "C | | | | | | | |
| | | | | | | Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 100+ | Boiling Point: *C | |
| | | | | | | Sample Wt 20 mg | 19 | Refractive Indax, no | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 27 | na | | | | | | | |
| | - • | n 👷 | | | | | | | |
| Friction Pendulum Test: | | Vacuum Stability Test: | | | | | | | |
| Steel Shoe Unaffec | ted | cc/40 Hrs, at | | | | | | | |
| Fiber Shoe Unaffec | ted | 90°C | | | | | | | |
| | | - 100°C | 0.26 | | | | | | |
| Rifle Bullet Impact Test; Trials | • | 120°C | | | | | | | |
| Sector Se | | 135°C | | | | | | | |
| Portials 0 | | 150°C | | | | | | | |
| Burned · 20 | | | | | | | | | |
| Unoffected 80 | | 200 Grem Bomb Sand Test: Sand, gm | 55.7 | | | | | | |
| | · | | | | | | | | |
| Explosion Temperatur :: *C | | Sensi ' ity to Initiation: | | | | | | | |
| Seconds, 0.1 (no cr.p used) | | Mir num Detonating Charge | e, gm | | | | | | |
| 1 5 290 | | Mercury Fulminate | | | | | | | |
| 10 | | Lead Azide | 0.20 | | | | | | |
| 15 | | Tetryi | 0.10 | | | | | | |
| 20 | | Bellistic Morter, % TNT: (a) |) 130 | | | | | | |
| 20 | | Trausi Test, % TNT: | | | | | | | |
| 75°C International Heat Test: | | | | | | | | | |
| % Loss in 48 Hrs | | Plote Dent Test: (c) | | | | | | | |
| | | Method | B | | | | | | |
| 100°C Heat Test: | | Condition | Hand tamped | | | | | | |
| % Loss, 1st 48 Hrs | 0.13 | Confined Density and (as | No 1.60 | | | | | | |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/cc | 115 | | | | | | |
| Explosion in 100 Hrs | None | Brisance, % TNT | | | | | | | |
| | | — Detension Rate: (d) | | | | | | | |
| Flammability Index: | | Confinement | None | | | | | | |
| Numerousiation (V and and and | ····· | Condition | Hand tamped | | | | | | |
| Hygroscopicity: % 30°C, 95% RH | N11 | Charge Diameter, in. | 1.0 | | | | | | |
| Volatility: | | Density, gm/cc | 1.59 | | | | | | |
| v oranihiy: | | Rote, ineters/second | 2040 | | | | | | |

| regmentation Test: | Shaped Charge Effectivaness, TNT = 100: | | | |
|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|--|--|
| 90 mm HE, M73 Projectile, Lot WC-91: | Gloss Cones Steel Cones | | | |
| Density, grr/cc | Hole Volume | | | |
| Charge Wt, Ib | Hole Depth | | | |
| Total No. of Fregments: | Color: Light brown | | | |
| For TNT | Come: Englis of Swill | | | |
| For Subject HE | Principel Uses: Plastic demolition explosi | ve | | |
| 3 inch HE, M42A3 Projectile, Let KC-5: | | | | |
| Density, gm/cc | | | | |
| Charge Wt, Ib | | | | |
| Total No. of Fragments: | Method of Loading: Hand tamped | | | |
| For TNT | taming of the second se | | | |
| For Subject HE | Loading Density: gm/cc 1.50 | | | |
| rogment Velocity: ft/sec | | | | |
| At 9 ft | | | | |
| At 251/2 ft | Storage: | | | |
| Density, gm/cc | Method Dry | | | |
| last (Reletive to TNT); | Hazard Class (Quantity-Distance) Cless 9 | | | |
| Air: | Compatibility Group Group I | | | |
| Peak Pressure | Exudation None at 77°C | | | |
| Impulse | Exudarion None at ((C | | | |
| Energy | ······································ | | | |
| * Air, Confinad: Impulse | Effect of Temperature on (i) Rate of Detonation: | | | |
| | 16 hrs at, °C -54 21 | | | |
| Under Water: Peak Pressure | Density, gm/cc 1.36 1.35 | | | |
| Impulse | Rate, m/sec 7020 7040 | , | | |
| Energy | Plasticity: | | | |
| | Below 0°C Plastic (-57°C | ;) | | |
| Underground: Peak Pressure | 0-40°C Plastic | , | | |
| Impulse | Above 40°C Plastic (77°C) | | | |
| Energy | | | | |
| | | | | |
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AMCP 706-177

Composition C-4

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

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Preparat'on:

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

Composition C-4 is prepared 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 ether. The thoroughly blended explosive is dried in sir at 60° C and loosely packed by hand tamping to its maximum density.

Origin:

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 $1 \frac{1}{4}$ parts sodium hydroxide, 11 parts water, and 4 parts 95% alcohol, heated to 50° C. After addition of Composition C-3 is complete, the solution is heated to 80° C and maintained at this temperature for 15 minutes.

References: 11

(a) Committee of Div 2 and 8, NDRC, Report on HBX and Tritonal, OSRD No. 5406, 31 July 1945.

(b) Philip C. Keensn 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.

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

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

M. D. Hurwitz, The Rate of Detonution of Various Compounds and Mixtures, OSR') Report No. 5611, 15 January 1946.

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

(1) Eastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Sec III, Variation of Cavity Effect with Explosive Covint 1100, NDRC Contract W672-ORD-5723.

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

(h) 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.

¹See footnote 1, page 10.

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Compositions C, C-2, C-3, Cal.

(i) W. F. McGarry and T. W. Stevens, <u>Detonation Rates of the More Important Military Explo-</u> sives at Several Temperatures, PATR No. 2383, November 1956.

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

| | ç | <u>1.</u> | 3 | 4 | 2 | <u>6</u> | I / | <u>8</u> | 2 |
|----------------------|------|-----------|--------------|------|----------------------|------------------------------|------|----------------------|------|
| Comp C | 1260 | | 1.293 | | | | .; | 1518 1838 | |
| Comp C-2 Comp C-3 | | 1611 | 1293 1713 | 215h | 1595 2695 1885 | 1416 1416 1556 1766 | 1797 | 1518 1518 2028 | |
| Comp C-4 | | | | | , | 1766 | 1907 | 1828 1958 | 1819 |

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AMCP 706-177

| Composition: | Aturcular Weight: (CuC2N8Cl2) 271 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| C 8.9 N-N | Oxygen Belance: |
| | CO % -30 |
| N 41.5 $\ddot{N} - N Cu$ | |
| C1 26.2 N-N | Denaity: gm/cc 2.04 |
| $Cu = 23.4$ $\frac{11}{N} - N$ $CC1$ | Meking Point: °C |
| C/H Rotio | Prezing Faint, "C |
| Impace Sensitivity, 2 Kg We: Bureau of Mines Apparatus, cm | Boiling Point: "C |
| Sample Wt 20 mg | Refractive Index, ng |
| Picatinny Arsenal Apparatus, in. 1; Sample Wt, mg | (1. 16 wt) 3 n ₄ |
| | y N p |
| Friction Pendulum Test: | Vacuum Stability Test: |
| Steel Shoe Exq | ploded cc/40 Hrs, at |
| Fiber Shoe Ext | ploded 90°C |
| | 160.0 |
| Ritle Builet Impact Test: Trials | 120*0 |
| % Explosions | 135°C |
| Partials | 130°C |
| Burned | 200 Course Branch Court Trank (A) |
| Unoffected | 200 Grath Bomb Sand Test: (\$) Sand. am. 27.4 25.3 |
| | Black porder fuse 27.4 25.3 |
| Explosion Temperature: "C | Service to Initiation: |
| Seconds, 0.1 (no cop used) | Minimum Determing Charge, gm |
| 1 | Mercury Fulminate |
| 5 305 | l cod Aride 0.20 0.30 |
| 10 | Tetryi 0.10 |
| 15 | Ballistic Morray, % YNT: |
| 20 | |
| 75°C International Heat Test: | Trauzi Test, % TNT: |
| % Loss in 48 Hrs | Plate Dext Test: Method |
| 100°C Hoat Test: | Cendition |
| % Loss, 1st 48 Hrs | 8.67 Confined |
| % Loss, 2nd 48 Hrs | 0.10 Density, gm/ur |
| Explosion In 100 Hrs | None Brisance, % TN? |
| Flammability Index: | Defendition Ruito: |
| THE REPORT OF THE PARTY OF THE | Confinement |
| Hygrascopicky: % 30°C, 90% RH | 3.11 Charge Diameter, in. |
| | Density, ym/cu |
| Volatility: | Rate, meters/second |

Copper Chlorotetrazole

| Fragmentation Test: | Shuped Charge Effectiveness, TNT = 100: | | | | |
|----------------------------------------|------------------------------------------------------------------|--------------------------------------------|--|--|--|
| 90 mm HE, M71 Projectile, Lot WC-91: | Glass Cones Si | test Cones | | | |
| Density, gm/cc | Hois Volume | | | | |
| Charge Wt, ib | Hole Depth | | | | |
| Total No. of Fragments: | Celer: | Blue | | | |
| For TNT | | Dine. | | | |
| For Subject HE | Principel Uses: Primary e | explosive | | | |
| 3 inch HE, M42A3 Projectile, Lot KC-S: | | | | | |
| Density, gm/cc | | | | | |
| Charge Wt, Ib | | | | | |
| Total No. of Frogments: | Method of Londing: Pa | ressed | | | |
| For TNT | memor of Locamy. | . 446 ¢u | | | |
| For Subject HE | | | | | |
| | | x 10 ³ (c) | | | |
| Fregment Velocity: ft/sec | 10 20 401.49 1.63 1.74 | 70 1.86 | | | |
| At 9 ft At 251/2 ft | Sterege: | | | | |
| Density, gm/cc | Method | Wet | | | |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance | e) Class 9 | | | |
| Airt | Cempatibility Group | Group M | | | |
| Peak Pressure | | | | | |
| impulse | Exudation | None | | | |
| Energy | | فماليه والرواحي فالمراجع والمراجع والمراجع | | | |
| Air, Confined: | Stab Sensitivity: | (c) | | | |
| Impulse | Density Firing Point (| neh-ounces) | | | |
| | <u>gm/cc 0% 50</u> | | | | |
| Under Water: Peak Pressure | 1.49 9 11 | 15 | | | |
| Impulse | 1.63 8.5 10 | 12 | | | |
| Energy | 1.74 6 7 | 9 | | | |
| m. m. 31 | 1.86 4 5 | 6 | | | |
| Underground: | Heat of: | : | | | |
| Peak Pressure Impulse | Explosion, cal/gm | 432 | | | |
| Energy | Specific Heat, cal/gm/°C | | | | |
| | | | | | |
| | Temp range O ⁰ -30 ⁰ C Wt of sample, gm | 0.155 0.8910 | | | |
| | | | | | |

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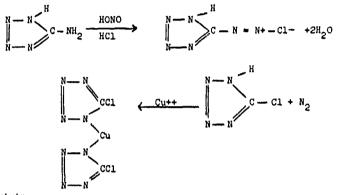
Copper Chlorotetrazole

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Preparation: (a)

Five grams of 5-aminotetrazole are dissolved in a mixture of 200 ml of water end 70 ml of concentrated HCL. Enough kerosene or nujol (which gives a slightly cleaner product) is added to provide a layer of oil approximately 1/4" thick on the surface. With only moderate stirring and external cooling to 10° - 15° C, a solution of 5 grams of sodium mitrite 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 5 gms of cupric chloride in a minimum amount of water is added all at once, and stirring is continued for about 1 hour. The reaction mixture is allowed to stand for a few minutes till the bright blue copper salt separates. The oil is removed by decentation and may be reused. The salt 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 reaction of the diazonium chloride of 5-aminotetrazole with copper chloride (Ber <u>62</u>A, 1123).

References: 12

(a) R. J. Gaughran and J. V. R. Kaufman, Synthesis and Properties of Halotetrazole Salts, PATR No. 2136, February 1955.

(b) A. M. Anzalone, J. E. Abel and A. C. Forsyth, <u>Characteristics of Explosive Substances</u> for <u>Application in Armunition</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 footnote 1, page 10.

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Cyanurie Triazide

| Composition: 96 | Molecular Weight: $(C_{y_{12}})$ | 204 |
|---------------------------------------------------------------------------------------------------------------------|----------------------------------|------------------|
| C 17.6 N ₃ | Oxygen Belence: COy % CO % | -47.1 -23.5 |
| | Density: gm/cc Crystal | 1.54 |
| N3-C C-N3 | Melting Point: *C | 94 |
| C/H Ratio | Froexing Point: *C | |
| Impact Sensitivity, 2 Kg We: | Boiling Paint: *C | |
| Bureau of Mines Apparatus, cm 1 kg vt 7 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. – Sample Wt, mg – | Refractive Index, ng ng ng | |
| Friction Pendulum Test: | Vecuum Stability Test: | |
| Steel Shoe | cc/40 Hrs, at 90°C | |
| Fiber Shoe | 100°C | |
| Rifie Bullet Impact Test: Trials | 120°C | |
| % Explosions | 135°C | |
| Partials | 150°C | • • |
| Burned | 200 Grem Some Sand Test: | |
| Unoffected | Sond, gm | 32.2 |
| Explosion Temperature: *C | Sensitivity te Inifiction: | |
| Seconds, 0.1 (no cap used) 252 | Minimum Detonating Charge, gm | |
| 1 | Mercury Fulminate | - |
| 10 | | 0.20 |
| 15 | Tetryl | 0.10 |
| 20 | Ballistic Morter, % TNT: | |
| | Trauzi Test, % TNT: | |
| 75°C International Heat Test: % 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 | |
| | Brisance, % TNT | |
| Explosion in 100 Hrs | | |
| Explosion in 100 Hrs | Detonation Rate: | |
| Explosion in 100 Hrs | Confinement | - |
| • | Confinement Condition | - |
| Explosion in 100 Hrs Flammability Index: | Confinement | - 0.3 1.15 |

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Cyanuric Triazide

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| Fregmentation Test: | Shaped Charge Effectiveness, TNT = 1 | 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 | Coler: Col | lorless | | |
| For Subject HE 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib | Principel Uses: Not used because of difficulty in controlling sensitivity. | | | |
| Total No. of Fregments: For TNT For Subject HE | Method of Loading: | Pressed | | |
| Fregment Velecity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Looding Density: gm/cc At 200 atmospheres At 800 atmospheres Storege: Mathod | 1.4 1.5 | | |
| Blast (Relative to TNT): | Hozard Class (Quantity-Distance) | Class 9 | | |
| Air: Peak Prossure Impulse Energy | Compatibility Group Exudation | Nons | | |
| Air, Confined: Impulse | | | | |
| Under Weter: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse Energy | | | | |

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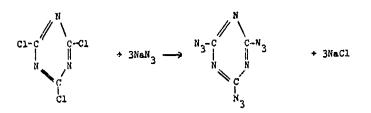
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Cyanuric Triazide

Preparation:

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



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

Origin:

Cyanuric Triazide was prepared in 1847 by Cabours from chlorine and mothyl cyanate. Later 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 saide. Cupable of inluisting Explosive D.

Solubility:

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

Heat of:

Formation, cal/gm

-1090 to -1138

References: 13

(a) A. H. Blatt, Compilation of Data on Organic Explosives, 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).

¹³See footnote 1, page 10.

Cyclonite* (RDX)

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| Composition: | | Molecular Weight: (C3H6N606) | 222 |
|---------------------------------------------------------------|-----------------|--------------------------------------|---------|
| C 16.3 02N-N N-1 | 10 ₂ | Oxygen Belance: CO ₂ % | -22 |
| н 2.7 н2 с | | | 0.0 |
| N 37.8 N | | Density: gm/cc Crystal | 1.82 |
| 0 43 <u>.2</u> NO ₂ | | Melting Point: *C | 204 |
| C/H Ratio 0.095 | | Freazing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 32 | Boiling Point: *C | |
| Sample Wt 20 mg | 8 | Refrective Index, ne | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 18 | កង | |
| · · · • | | n | |
| Friction Pendulum Test: | • | Vecuum Stebility Test: | |
| Steel Shoe Explode | 19 | cc/40 Hrs, at | |
| Fiber Shoe Unaffed | ted | 90°C | |
| Rifle Bullet Impact Test: Trials | | | 0.7 |
| % | | 120°C | 0.9 |
| Explosions 100 | | 135°C | • |
| Portials O | | 150°C | 2.5 |
| Burned O | | 200 Grem Bomb Send Test: | |
| Unaffected 0 | | Sand, gm | 60.2 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) 405 | | Minimum Detonating Charge, gn | n |
| 1 316 | | Mercury Fulminate | 0.19# |
| 5 Decomposes 260 | | Lead Azide | 0.05* |
| 10 240 | | * Alternative initiating chan | - |
| 15 235 20 - | | Ballistic Morter, % TNT: (a) | 150 |
| ٠ | | Trouxi Test, % TNT: (b) | 157 |
| 75°C International Haat Test: | | Plate Dunt Test: (c) | |
| % Loss in 48 Hrs | 0.03 | Method | A |
| 100°C Hest Test: | | Condition | Pressed |
| % Loss, 1st 48 Hrs | 0.04 | Confined | Yes |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/cc | 1.50 |
| Explosion in 100 Hrs | None | Brisance, % TNT | 135 |
| | | Dutonation Rate: | |
| Fiammebility Index: (d) | 278 | Confinement | None |
| · · · · · · · · · · · · · · · · · · · | | Condition | Pressed |
| Hygroscopicity: % 25°C, 100% RH | 0.02 | Charge Diameter, in. | 1.0 |
| Ad . 1 | AT.1 3 | Density, gm/cc | 1.65 |
| Volatility: | Nil | Rate, meters/second | 8180 |

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

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Cyclonite (RDX)

| | | · · · · |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|---------|
| Booster Sensitivity Test: Condition | Decomposition Equation: (1) Oxygen, atoms/sec 10 ^{18,5} | |
| Tetryl, gm | (Z/sec) | |
| Wax, in. for 50% Detonation | Heat, kilocatorie/mole 47.5 (AH, kcal/mol) | · |
| Wax, gm | Temperature Ronge, *C 213-299 | |
| Density, gm/cc | Phase Liquid | |
| Heet of: Combustion, cal/gm 2285 | Armer Plate Impoct Test: | |
| Explosion, cal/gm 1280 | de la chia da Barbardia | |
| Gas Volume, cc/gm 908 | 60 mm Marter Projectile: 50% Inert, Velocity, ft/sec | |
| Formation, cal/gm -96 | Aluminum Fineness | |
| Solution, cal/mol (28-55% HNO3) 7.169* | | |
| Assuming cyclonite unimolecular | 500-ib Ganeral Purpose Bombs: | |
| Specific Heat: col/gm/°C | | |
| ° <u>c</u> ° | Plate Thickness, inches | |
| 20 0.298 100 0.406 | 1 | |
| 40 0.331 120 0.427 | 11/4 | |
| 60 0.360 140 0.446 80 0.384 | 11/2 | |
| | 174 | |
| Surning Rate: | | |
| cm/sec | Bemb Drop Test: |]. |
| Thermel Conductivity: (h) col/sec/cm/*C 1.263 6.91 x 10 ⁻¹⁴ Density, gm/cc 1.533 6.98 x 10 ⁻¹⁴ | T7, 2000-1b Semi-Armor-Piercing Bemb vs Concrete: | į |
| Coefficient of Expansion: | Max Safe Drop, ft | |
| Linear, %/^C | 500-lb General Purpose Bomb vs Concrets: | |
| Volume, %/*C | Height, ft | |
| | Trials | |
| l'erdness, Mohs' Scele: 2.5 | Unaffected | |
| Young's Modulus: | l.ow Order | |
| E', dynes/cm ² | High Order | |
| E, lb/inch ² | | 1 |
| Density, gm/cc | 1000-16 General Purpose Bomb vx Concrete: | |
| Denarry, giny co | Height, ft | |
| Compressive Strength: Ib/inch ² | Trials | |
| • | Unoffected | 1 |
| | Low Order | |
| Vapor Pressure: *C mm Mercury | High Order | |
| ··· , | | |
| | | - |
| | | , |
| | | |

| Fragmentation Test: | Shaped Charge Effectivaness, 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 Fregments: | Color: White |
| For TNT | Color: White |
| For Subject HE | |
| | Principal Uses: Detonator base charge, and |
| 3 inch HE, M42A1 Projectile, Lot KC-5: | ingredient for projectile and bomb fillers |
| Density, gm/cc | |
| Charge Wt, Ib | |
| Total No. of Fragmants: | Method of Loading: Pressed |
| For TNT | |
| For Subject HE | |
| | Loading Density: gm/cc psi x 10 ³ 3 5 10 12 15 2 |
| Fragment Velocity: ft/sec | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ |
| At 9 ft | |
| At 251/2 ft | Storage: |
| Density, gm/cc | Method Wet |
| Blast (Reletive to TNT): | Hazard Class (Quantity-Distance) Class 9 |
| Air: | Compatibility Group Group M (wet) |
| Peak Pressure | Group L (dry) |
| Impulse | Exudation None |
| Energy | |
| Air, Confined: | Effect of Temperature on Rate of Detonation: (k) |
| impulse | |
| | 16 hrs at, °C -54 21 |
| Under Water: Peak Pressure | Density, gm/cc 1.61 1.62 Rate, m/sec 8100 8050 |
| | Rate, m/sec 8100 8050 |
| Impulse Energy | Effect of Temperature on Impact Sensitivity: |
| | |
| Underground: | Temp. PA Impact Test |
| Peak Pressure | OC 2Kg Wt, inches |
| Impulse | Room 9 |
| Energy | Room 9 32.2 8 104 5 |
| | |
| | 1 |

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Cyclonite (RDX)

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|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Water | Alcohol | Acetone | Benzene | Toluene |
| $\begin{array}{c} \circ_{\rm C} & -\frac{6}{2} \\ 30 & 0.005 \\ 50 & 0.025 \\ 70 & 0.076 \\ 90 & 0.19 \\ 100 & 0.28 \end{array}$ | ос <u>у</u> 0 0.040 20 0.105 40 0.240 60 0.579 78 1.195 Сагъса | $\begin{array}{c} \circ c & \frac{4}{5} \\ \hline 0 & 4.1 \\ 20 & 7.3 \\ 40 & 11.5 \\ 60 & 18. \end{array}$ | ° <u>c</u> <u></u> 20 0.05 40 0.09 60 0.20 80 0.41 | $\begin{array}{c cccccc} & & & & & \\ \hline 0 & 0.015 \\ 20 & 0.02 \\ 40 & 0.05 \\ 60 & 0.13 \\ 80 & 0.30 \\ 100 & 0.65 \end{array}$ |
| Ethyl acetate | tetrachloride | Methanol | Ether | INT |
| <u>°c 4</u> 28 2.9 94 18. | <u>°c </u> <u></u> 50 0.005 60 0.007 70 0.009 | $ \begin{array}{cccc} $ | <u>°c%</u> 10 0.05 20 0.056 30 0.076 | oc % 80 4.4 85 5.0 90 5.55 95 6.2 100 7.0 105 7.9 |
| Isoamy1 slcohol | Methyl aceiate | <u>B-Ethoxyethyl</u> acetate | Chlorobenzene | Trichloro- ethylene |
| $\begin{array}{c} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 $ | <u>°C</u> <u>4</u> 20 2.9 30 3.3 40 4.1 50 5.6 | $\begin{array}{ccc} \circ_{\rm C} & \frac{9}{20} \\ 20 & 0.15 \\ 30 & 0.16 \\ 40 & 0.19 \\ 50 & 0.25 \end{array}$ | <u>oc</u> <u>4</u> 20 0.33 30 0.44 40 0.56 50 0.74 | oc \$ 20 0.20 30 0.22 40 0.24 50 0.26 |
| <u>Tetra-</u> chloroethane | Isopro- panol | Isobutanol | Chloroform | Mesityloxide |
| <u>°c 5</u> 38 0.09 | <u>°C %</u> 38 0.18 | <u>°c</u> <u>*</u> 20 0.0 | <u>°c %</u> 20 0.01 | <u>°c</u> ∦ 27 3.2 97 12.2 |
| Cyclo- hexanone | <u>Nitro-</u> benzene | Nitro- ethane | Cyclo- pentanone A | cetonitrile |
| $\frac{\circ_{C}}{25}$ $\frac{4}{12.7}$ 97 25 | $\frac{\circ c}{25}$ $\frac{4}{1.5}$ 97 12.4 | <u>°c 4</u> 29 3.6 93 19 | <u>°c %</u> 28 11.5 90 37 | <u>°c 4</u> 28 11 82 33 |
| | Methy] | ethyl ketone | | |
| | <u>°c</u> 28 95 | - <u>%</u> 5.6 14 | | |

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

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Solubility of Cyclonite, Holston Lot E-2-5 ir Various Solvents:

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| | | | gr | lubility n/100 gm Solvent | |
|-----------------------|------------------------|---------------------|-------------|---------------------------------------|--------------------------------|
| Solvent | Boiling Point, C | Grade or Source | <u>28°c</u> | Heated | Crystalline Form |
| Acetone | 56 | CP | 8.2 | 16.5 at 60°C | hexagonal-thick |
| Cyclohexanone | 155.6 | CP | 13.0 | 24.0 at 93°C | cubic (massive form) |
| Ni trome thane | 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-Nit.opropane | 126.5 | EX Pract | 1.4 | 10.6 at 93°C | short needles |
| 2-Nitropropane | 120 | EK Pract | 2.3 | 11.6 at 93°C | short needles |
| 2,4-Pertanedione | 140.5 | Carbide & Carbon | 2.9 | 18.3 at 93°C | flat prisms |
| Methylisobutylketone | 115.8 | | 2.4 | $9.6 \text{ at } 93^{\circ}$ C | long prisms |
| n-Propylacetate | 101.6 | EK Red Label | 1.5 | 6.0 at 93°C | long prisms, some |
| n-Butylformate | 105.6 | EK Red Label | 1.4 | 4.6 at 93°C | long prisms |
| Ethyl acetste | 77.1 | Baker's CP | 2.0 | 6.1 at boil. | hexagonal plates |
| n-Propylpropionate | 121 | EK Red Label | 0.8 | 1.6 et 93°C | short prisms, some cubic |
| Butylacetate | 126.5 | EK Technical | 1.1 | $4.0 \text{ at } 93^{\circ}\text{C}$ | long prisms |
| Methylethylketone | 79.6 | | 5.6 | 13.9 at boil. | coarse plates |
| Nitroethane | 114.2 | EK Red Label | 3.6 | 19.5 at 93°C | plates |
| Isopropylacetate | 88-90 | CP | 1.1 | 3.2 at boil. | long prisms |
| Mesityloxide | 128 | EK Red Label | 4.8 | $14.5 \text{ at } 93^{\circ}\text{C}$ | plates |
| n-Amylacetate | 16 | CP | 1.0 | 2.1 at 93°C | prisms |
| Dimethylcarbonate | 88-91 | EK Red Label | 1.4 | 6.6 et boil. | plates |
| Diethylcarbonate | 125-126.5 | EK Red Label | 0.7 | 3.1 41 9300 | prisms |
| Isoamylacetate | 1.32 | CP | 1.2 | 5.6 at 93°C | prisms |
| Ethylpropionate | 98-100 | EK Red Label | 3.0 | 10.7 at 93°C | fairly thick hex plates |
| Methyl-n-butyrate | 101.5-103.5 | EK Red Label | 1.2 | 4.9 at 93°C | needles |
| Cyclopentanons | 130.6 | EK Red Label | 11.5 | 39.0 at 93.5° | |
| Acrylonitrile | 77.3 | Cyanamid Co. | 4.0 | 16.4 at boil. | flat plates |
| Methylcellosolveaceta | | Carbide & Curbon | 1.6 | 8.8 at 93°C | massive hexagons and prisms |

* EK, Eastman Kodak; Pract, practical.

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Cyclonite (RDX)

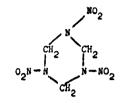
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Preparation:

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

1.....

(CH2)6 N1 + 'HNO3 + 2N LNC3 + 6(CH3CO)2 0



Armonium nitrate and acetic anhydrids 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 hexaminy in glacial acetic acid. The final mixture is held for a short time at 75° C, diluted with water to 30% acetic acid, and simulated to hydrolyze unstable reaction by-products, which are a mixture of various nitrated and acetylated derivatives of hexamine fragmonts. 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 welting at 195°C. By dissolving the amaonium nitrate in the nitric soid, a continuous process, based on 3 liquids, is possible.

The product is recrystillized from acetons, or cyclobexanone, .o (a) remove acidity, (b) control particle size and (c) to produce stable B-HMX. The preparative procedure described above, the Bachmann or Co: instion process, yields cyclonite containing 3-8% HMX.

Origin:

First prepared by Honning in 1899 (German Patent 104,280) and later by von Hertz (U. S. Patent 1, 102,693) in 1922 who recognized its value as an explosive. Not used on a large scale in employive ammunition unti. 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-balf hour.

References: 14

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

- (b) Ph. Naoum, Z. ges Schiess Sprengstoffw, pp. 181, 229, 267 (27 Juna 1932).
- (c) D. P. MacDougall, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

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

¹⁴See footnote 1, page 10.

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

(f) Heport AC-2587.

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(g) International Critical Tables Land. Bornst.

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

(h) E. Mutchinson, The Thermal Sensitiveness of Explosives. The Thermal Conductivity of Explosive Materials, AC 2561, First Report, August 1942.

(i) R. J. Finkelstein and G. Gamov, 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, <u>Detonation Rates of the More Important Military Explo-</u> sives at Several Different Temperatures, MAR No. 2333, November 1956.

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

| <u>o</u> | 1 | 2 | <u>3</u> | 4 | ź | 6 | I | <u>8</u> | 2 |
|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------------------------------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| 1170 1290 1360 1450 1760 1930 2100 | 1211 1241 1311 1421 1421 1421 1561 1611 1651 1741 1751 1761 2131 2151 | 502 1342 1352 1372 1402 1452 1492 1532 2062 2112 | 863 1193 1293 1433 1503 1693 1713 1793 1923 | 1184 1414 1454 1614 1634 2024 2154 2204 | 65 1175 1185 1435 1445 1445 1445 1445 1445 1445 144 | 1236 1316 1416 1466 1476 1556 1756 1756 1756 1756 1756 1756 17 | 857 1407 1437 1517 1517 1617 1687 1797 1797 1797 1997 2227 | 24 38 24 58 14 98 15 78 18 38 19 58 19 58 20 28 20 28 20 28 21 78 21 98 | 709 1379 1429 1449 1469 1709 1909 2059 2179 |

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Cyclotol, 75/25

| Composition: | Molecular Weight: | 224 | | |
|---------------------------------------------------------------|-----------------------------------------------------------------------------|---------------------|--|--|
| | Oxygen Belance: | | | |
| RDX 75 | CO, % | -35 - 6 | | |
| TNT 25 | CO % | • 0 | | |
| | Density: gm/cc Cast | 1.71 | | |
| | Making Point: "C | | | |
| C/H Ratio | Freezing Point: "C | | | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Boiling Point: *C | | | |
| Sample Wt 20 mg | Refrective Index, no | | | |
| Picatinny Arsenal Apparatus, in. | n _{as} | | | |
| Sample Wt, mg | n2 | | | |
| Friction Pendulum Test: | | | | |
| Steel Shoe Unaffected | Vacuum Stability Test: | | | |
| Fiber Shoe Unaffected | cc/40 Hrs, at 90°C | r | | |
| | | 0.23 | | |
| Rifie Bullet Impact Test: Trials | 120*C | 0.41 | | |
| % | 135*C | - 1 | | |
| Explosions 30 | 150°C | | | |
| Partials Smokes 40 | | | | |
| Burned 0 | 200 Gram Bomb Sand Test: | | | |
| Unaffected 30 | Sond, gm | | | |
| Explosion Temperature: *C | Sensitivity to Initiation: | | | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | | | |
| 1 | Mercury Fulminate | | | |
| 5 | Lead Azide | | | |
| 10 | Tetryl | | | |
| 15 20 | Ballistic Mortor, % TNT: | | | |
| | Trouzi Test, % TNT: | | | |
| 75°C International Heat Yest: % 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 | Brisonce, % TNT | | | |
| | Datenation Rate: | | | |
| Flammability Index: | Confinement None | None | | |
| | Condition Cast | Cast | | |
| Hygroscopicity: % | | | | |
| · · · · | | | | |
| Volatility: | arender y ginty as | | | |
| | Charge Diameter, in. 1.0 Density, gm/cc 1.70 Rate, meters/second 8035 | 1.0 1.71 7938 | | |

Cyclotol, 75/25

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AMCF 706-177

| Boosto? Sansitivity Test: | Decomposition Equation: |
|---------------------------------------------------------|---------------------------------------------------|
| Condition | Oxygen, atoms/sec (Z/sec) |
| Tetryl, gm | Heat, kilocalorie/mole |
| Wax, in. for 50% Detonation | (SH, kcal/mol) |
| Wax, gm | Temperature Range, *C |
| Density, gm/cc | Phase |
| Heat of: Comb stion. cal/am 2625* | Armer Plete impect Test: |
| | |
| | 60 mm Morter Projectije: |
| daa voibine, ce/gni | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | Aluminum Fineness |
| Fusion, col/gm (h) 5.0 | |
| *Calculated from composition of mixture. | 500-lb General Purpose Bombs; |
| Specific Heet: cul/gm/*C (h) <u>°C [°]C</u> | Plate Thickness, inches |
| | |
| -75 0.220 75 0.352 | 1 |
| 0 0.225 85 0.325 25 0.254 90 0.332 | 14 |
| 50 0.296 100 0.351 | 114 |
| | 191 |
| Burning Rate: cm/sec | Bomb Drop Test: |
| Thermal Canductivity: | |
| cal/sec/cm/*C | T7, 2000-lb Semi-Armer-Piercing Bomb vs Concrete: |
| Coefficient of Expension: | Max Safe Drop, ft |
| Linear, %/*C | 500-ib General Purpose Bomb vs Concrete: |
| Volume, %/*C | Height, ft |
| | Trials |
| Hardness, Mohs' Scale: | Unaffected |
| | Low Order |
| Young's Modulus: | High Order |
| E', dynes/cm² | |
| E, Ib/inch ² | 1000-ib General Purpose Bomb vs Concrete: |
| Density, gm/cc | |
| | Height, ft |
| Compressive Strength: Ib/inch ² | Triols |
| | Unoffected |
| Vapor Pressure: | Low Order |
| *C inm Mercury | High Order |
| | |
| | |
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Cyclotol, 75/25

| Frigminitation Test: | | Shaped Charge Effectiveness, THT = 100: | | |
|-----------------------------------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------|---------------------|--|
| 90 mm NS, M71 Projectile, Lot WC-91: | | Glass Cones Steal Cones | | |
| Dansity, gm/cc | 1,72 | Hole Volume | ľ | |
| Charge Wt, ib | 2.22 | Hole Depth | | |
| Total No. of Fregments: | | Celer: Yellowbi | | |
| For TNT | 703 | Yellow-bu | 111 | |
| For Subject HE | 1514 | Principel Uses: Shaped charge bomb especi | | |
| 3 inch HE, M42A1 Projectile, I | Let KC-5: | | on; HE projectiles; | |
| Density, gm/cc | | grenades | | |
| Charge Wt, Ib | | | | |
| | | | | |
| Total No. of Fregments: For TNT | | Method of Loading: | Cast | |
| For Subject HE | | Losding Density: gm/cc | 1.71 | |
| | | | 1.11 | |
| Fragment Velocity: ft/sec At 9 ft At 251/4 ft | | Storage: | | |
| Density, gm/cc | | | | |
| · · · · · · · · · · · · · · · · · · · | | Method | Dry | |
| Blast (Relative to THT): | (d) | Hozard Class (Quantity-Distan | ce) Class 9 | |
| Air: | • | Compatibility Group | Group I | |
| Peak Pressure | 111 | | - | |
| Impulse | 126 | Exudation | | |
| Energy | | | | |
| | | Preparation: See Composition | on B | |
| Air, Confined: Impulse | | Origin: Developed by the British between World Wars I and II and stendarwized in the United States early in World War II. | | |
| Under Water: Peak Pressure | | Black Modulus at Room Temperature (25°-30°C): | | |
| Impulse | | Dynes/cm ² x 10-10 | 3.09 | |
| Energy | | Density, gm/cc | 1.74 | |
| Underground: | | Absolute Viscosity, poises Temp, 85 C | 210** | |
| Peak Pressure | | 90 ⁰ C | | |
| Impulse | | Efflux Vincosity, Seybolt | Seconds: | |
| Energy | | тещ , 85 ⁰ С | 9-14 | |
| | | Compositions using Spec (Class A RDX. Composition prepared using particle size. | 1 | |

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Cyclotol, 70/30

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| Composition: | Molecular Weight: | 224 |
|------------------------------------------------------------------|---------------------------------------|------------|
| RDX 70 | Oxygen Balance: | |
| • | CO, % CO % | -37 - 8 |
| TNT 30 | CO % | - 0 |
| | Density: gm/cc Cast | 1.71 |
| | Melting Point: *C | |
| C/H Ratio | Freezing Point: *C | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 60 | Boiling Point: "C | |
| Sample Wt 20 mg | Refractive Index, no | |
| Picatinny Arsenal Apparatus, in. 14 | n | |
| Sample Wt, mg 20 | n <mark>o</mark> n | |
| Friction Pendulum Test: | Vacuum Stability Test: | <u></u> |
| Steel Shoe Unaffected | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | |
| Rifle Bullet Impact Test: Trials | 100°C | - 04 |
| Kitle Buller Impoct Test: Tricis / | 120°C | 0.86 |
| Explosions 30 | 135°C | |
| Portials 30 | 150°C | |
| Burned O | 200 Gram Bamb Sand Test: | |
| Unoffected 40 | Sand, gm | 56.6 |
| Explosion Temperature: ¹ C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) - | Minimum Detonating Charge, g | |
| 1 - 5 Decomposes 265 | Mercury Fulminate | 0.21* |
| 10 | Lead Azide | 0.20* |
| 15 | Tetryl *Alternative initiating cha | rzes. |
| 20 | Ballistic Mortor, % TNT: (8) | 135 |
| | Truuzi Test, % TNT: | |
| 75°C Internetional Heat Yest: % Loss in 48 Hrs | Plate Dant Test; (b) | |
| 70 - Luga III 40 FIIS | Method | в |
| 100°C Heat Test: | Condition | Cast |
| % Loss, 1st 48 Hrs 0.07 | Contined | No |
| % Loss, 2nd 4' Hrs 0.08 | Density, gm/cc | 1.725 |
| Explosion in 100 Hrs None | Brisance, % TNT | 136 |
| RhannachiPhan Indone | Detonation Rate: | |
| Flemmability Index: | Confinement | None |
| Hygroscopicity: % Nil | Condition | Cast |
| ······································ | Chorge Diamster, in. | 1.0 |
| Velatility: N11 | Density, gm/cc | 1.73 |
| ······ | Rate, meters/second | 8060 |

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Cyclotol, 70/30

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| Fregmentation Tost: | | Sheped Charge Effectivaness, TN | r = 100: |
|---------------------------------|----------|-----------------------------------------------------------------------------|-----------------|
| 90 mm HE, M71 Projectila, Lo | WC-91: | Glass Cones S | iteel Cones (e) |
| Density, gm/cc | 1.71 | Hole Volume | |
| Charge Wt, Ib | 2.213 | Hole Depth | 130 |
| Total No. of Fragments: | | Cebr: | Yellow-buff |
| For TNT | 703 | | 161104+0011 |
| For Subject HE | 1165 | Priscipel Uses: Shaped charge | bombar |
| 3 inch HE, JA42A1 Projectile, L | 44 KC-5: | especially fr | mgmentation HE |
| Density, gm/cc | 1.72 | projectiles, | grenades |
| Charge Wt, Ib | 0.923 | | |
| Total No. of Fragments: | | | |
| For TNT | 514 | Method of Londing: | Cast |
| For Subject HE | 828 | | |
| 18 - 19 a | | Loading Density: gm/cc | 1.71 |
| regment Velocity: ft/sec | | | |
| At 9 ft At 25½ ft | | ·Storage: | |
| Density, gm/cc | | | |
| | | Method | Dry |
| last (Relative to TNT): | (d) | Hazard Closs (Quantity-Distanc | e) Class 9 |
| Air: | | Compatibility Group | Group I |
| Peak Pressure | 110 | | |
| linpulse | 120 | Exudation | |
| Energy | | | |
| Air, Cerfined: | | Preparation: See Compositio | n B |
| Impulse | | Origin: Developed by the Br World Wars I and II and | |
| Under Water: | | the United States early | in World War II |
| Peak Pressure | | Absolute Viscosity, poises: | * |
| Impulse | | Temp. 85°C | |
| Energy | | 90 ⁰ C | 53.2 |
| Ded. source de | | Efflux Viscority, Saybolt S | |
| Underground: Peak Pressure | | Temp, 85°C | 5 |
| Impulse | | Heat of: | ** |
| Energy | | Combustion, cal/gm | 2685 |
| | | Explosion, cal/gm Gas Volume, cc/gm | 1213 854 |
| | | * Composition using Spec Gr Class A RDX. ** Celculated from compositi | |

Cyclotol, 65/35

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| والمحاد الأقاد بالمحاد والمحاد والمح | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|------------|
| Composition: 46 | Molecular Weight: | 224 |
| RDX 55 | Oxygen Balance: | |
| יזאיז 35 | CO, % CO % | -40 - 9 |
| TNT 35 | | • 9 |
| | Density: gm/cc Cast | 1.71 |
| | Melting Point: *C | |
| C/H Ratio | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Boiling Point: *C | |
| Sample Wt 20 mg | Refractive Index, no | |
| Picetinny Arsenal Apparatus, in, Sample Wt, mg | D 23 | |
| | ns | |
| Friction Pendulum Test: | Vecuum Stability Test; | |
| Steel Shoe Unaffected | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | |
| Rifle Bullet Impect Test: Triala | 100°C | |
| - | 120°C | |
| % Explosions | 135°C | |
| Partials | 150°C | |
| Burned | 200 Gram Bomb Sand Test; | |
| Unoffected | Sand, gm | 55.4 |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | |
| 1 | Mercury Fulminate | |
| 3 Decomposes 270 | Lead Azide | |
| 10 | Tetryl | |
| 20 | Ballistic Morter, % TNT: (a) | 134 |
| | Trauxi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dant Test: Method | |
| 100 °C Heat Test: | Condition | |
| % Loss, ist 48 Hrs | Confined | , |
| 96 Loss, 2nd 48 Hrs | Density, gm/cc | |
| Explosion in 100 Hrs | Brisonce, % TNT | |
| | Detonation Rate: | |
| Flasamability Index: | Confinement | None |
| | Crudition | Cast |
| Hygroscopicity: % Nil | Chorge Diameter, in. | 1.0 |
| ······ | Density, gm, cc | 1.72 |
| Veletility: Nil | Rote, meters/second | 7975 |
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AMCP 706-177

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Cyclotol, 65/35

| Fragmentation Test: | · | Shaped Charge Effectiveness, THT == 1 | 00: |
|---------------------------------------------------|-------------|----------------------------------------------------------------|-------------------|
| 90 mm HE, M71 Proj- w, Lo | • WC-91: | Glass Cones Steel C | Ion es (e) |
| Density, gm/cc | 1.71 | Hole Volume | |
| Charge Wt, Ib | 2.253 | Hole Depth 130 | |
| Total No. of Fragments: | | Calor: Kallar bu | |
| For TNT | 703 | Yellow-bu | ff |
| For Subject HE | 1153 | Principal Uses: Shaped charge bom | |
| 3 inch HE, M42A1 Projectile, L | of KC-S: | especially fragme projectiles, gren | |
| Density, gm/cc | 1.71 | projecties, grea | aues |
| Charge Wt, Ib | 0.922 | | |
| Total No. of Fragments: | | Method of Londing: | Cast |
| For TNT . | 514 | | |
| For Subject HE | 769 | Loading Density: gm/cc | 1.71 |
| Provide Martin States | | | |
| Fregment Velecity: ft/sec At 9 ft At 25½ ft | | Sterege: | |
| Density, gm/cc | | | |
| | | Method | Dry |
| Blast (Relative to TNT): | | Hazard Class (Quantity-Distance) | Class 9 |
| Air: Peak Pressure | | Compatibility Group | Group I |
| | | Exudation | |
| Impulse | | | |
| Energy | | | |
| Air, Confined: | | Preparation: See Composition B | |
| Impulse | | Origin: Developed by the Britis | |
| | | World Wars I and II and stand the United States early in Wo | |
| Under Woter: Peak Pressure | | the United States early in we | uld Met 71: |
| | | Eutectic Temperature, ^O C: | 79 |
| Impulse | | gm RDX/100 gm TNT | |
| Energy | | 79°C | 4.16 |
| Underground: | | 95°C | 5.85 |
| Peok Pressure | | Absolute Viscosity, poises:* | } |
| Impulse | | | 1 |
| Energy | | Темр, 85°С 90°С | 30.2 26.0 |
| Heat of: | * | * Composition using Spec Grade | |
| Combustion, cal/gm | 2755 | Class A RDX. | -9 8-4 111 |
| Explosion, cal/gm | 1205 845 | | |
| Gas Volume, cc/gm * Calculated from compos | • | | |
| | | | |

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Cyclotol, 60/40

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| | Molecular Weight: | 224 |
|------------|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 60 | Oxygen Belanca: | |
| 00 | | -43 |
| 40 | CO % | 10 / |
| | Density: gm/cc Cast | 1.68 |
| | Melting Point: *C | · |
| | Freezing Point: "C | [™] a _{isp} t |
| 75 | Boiling Point: *C | • |
| 14 | Refrective Index, na | |
| | n | |
| | ns | |
| | Vacuum Stability Test: | ····· |
| Unaffected | cc/40 Hrs, at | |
| Unaffected | | |
| | | |
| | | 0.29 |
| | | |
| | 150*C | |
| | 200 Gram Bomb Sund Test: | |
| | Sond, gm | 54.6 |
| | Sensitivity to Initiation: | |
| | | |
| | | 0.22* |
|) | | 0.20* |
| | *Alternative initiating charg | es. |
| | Ballistic Mortar. % TNT: (a) | 1.33 |
| | Trauzi Test, % TNT: | |
| | Plate Dent Test: (b) | |
| | Method | В |
| | Condition | Cast |
| | Confined | No |
| | Density, gm/cc | 1.72 |
| | Brisonce, % TNT | 132 |
| <u>+</u> | Detention Rete: | N |
| | | None |
| | Condition | Cast |
| NII | | |
| Nil | Charge Diameter, in. Density, gm/cc | 1.0 1.72 |
| | 75 14 19 | 60 Oxygen Belence: CO. % CO. % 40 Density: gm/cc Cast Melting Point: "C Freezing Point: "C Freezing Point: "C 75 Boiling Point: "C 75 Refrective Index, n% n% n% 14 n% 19 n% 10 C 100°C 120°C 135°C 150°C 200 Gram Bomb Sund Test: Sand, gm Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminote Lead Azide Ternyl *Alternetive initiating charge Bellistic Morter. % TNT: (b) Mathod Confined Density, gm/cc |

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AMCP 706-177

Cyclotol, 60/40

| Fragmentation Test: | | Shaped Charge Effectiveness, TNT == | 100: |
|----------------------------------------|------------------|-------------------------------------------------|---------------|
| 90 mm HE, X71 Projectile, Lot | WC-91: | Glass Cones Steel | Cones (e) |
| Density, gm/cc | 1.65 | Hole Volume 178 | 162 |
| Charge Wt, Ib | 2.187 | Hole Depth 125 | 148 |
| Total No. of Fragments: | | Color: Yel: | l ow-buff |
| For TNT | 703 | | |
| For Subject HE | ·98 | Principal Uses: Shaped charge be | |
| 3 inch HE, M42A1 Projectile, Lo | ł KC-5: | especially frag projectiles, gro | |
| Density, gm/cc | 1.67 | , | |
| Charge Wt, Ib | 0.882 | | |
| Total No. of Fragments; | | Method of Loeding: | Cast |
| For TNT | 514 | | •••• |
| For Subject HE | 701 | Loading Density: gm/cc | 1.68 |
| Fragment Velocity: ft/sec | (c) | | 1.00 |
| At 9 ft At 25½ ft | 2965 2800 | Storage: | |
| Density, gm/cc | | | |
| | | Method | Dry |
| Blast (Relative to TNT): | (d) | Hazard Class (Quantity-Distance) | Class 9 |
| Air: | | Compatibility Group | Group I |
| Peak Pressure | 104 | F 1.1 | |
| Impulse | 116 | Exudation | |
| Energy | | | ····· |
| Air, Confined: | | Preparation: See Composition | 8 |
| Impulse | | Origin: Developed by the Brit: | ish between |
| | | World Wars I and II and star | ndardized in |
| Under Weter: Peak Prossure | | the United States early in I | World War II. |
| Impulse | | Bulk Modulus at Room | |
| Energy | | Temperature (25°-30°C): | |
| | | $Dynes/cm^2 \times 10^{-10}$ | 4.14 |
| Underground: Peak Pressure | | Density, gm/cc | 1.72 |
| Impulse | | Absolute Viscosity, poises:* | |
| Energy | | Temp, 85°C | 12.3 |
| Heat of: | * | 90°C | · •= |
| Combustion, cal/gm | 2820 | | |
| Explosion, cal/gm Gas Volume, cc/gm | 1195 845 | * Compositions using Spec Grade Class A RDX. | г туре А, |
| Compressive Strength: 1b/i | nep ² | | |
| 1.70 _m/cc | 2200-3000 | | |

* Calculated from composition of mixture.

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Cyclotol, 75/25, 70/30, 65/35

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References: 15

(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>, OSRD Report No. 5746, 27 December 1945.

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

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

(d) V. Philipchuk, Free Air Blast Evaluation of RDX-TNT-Al, RDX-TNT, and TNT-Metal Systems, National Northern Summary Report, NN-P-34, April 1956.

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

(f) W. S. Cramer, Bulk Compressibility Data on Several High Explosives, NAVORD Report No. 4380, 15 September 1956.

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

| <u>v</u> | <u>1</u> | 2 | 3 | <u>4</u> | ٤ | 6 | <u>7</u> | 8 | 2 |
|--------------|--------------|------|-----------------------|------------------------------|--------------|------------------------------|----------------------|----------------------|----------------------|
| 1290 1530 | 1651 1741 | 1482 | 1483. 1793 1983 | 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, PAIR No. 2504, January 1959.

¹⁵See footnote 1, page 10.

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Cyclotrimethylene Trinitrosamine

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| Composition: H % 12 | Molecular Weight: (C3H6N603) | 174 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|------------|
| c 20.6 | Oxyge Balance: | |
| H 3.5 0-N-N - N-N= | -0 CO % | -55 -28 |
| N 48.3 H ₂ C CH ₂ | Density: gm/cc | |
| 0 27.6 N | Meiting Point: *C 105 | to 107 |
| C/H Ratio 0.12 | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: | Boiling Point: 'C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | Refrective Index, no | |
| Picatinny Arsenal Apparatus, in. 15 to 22 | n ^D | |
| Sample Wt, mg 17 to 20 | n 🐱 | |
| Friction Pandulum Test: | Vacuum Stability Test: | (c) |
| Steel Shoe Unaffect | | |
| Fiber Shoe Unaffect | | |
| Rifle Bullet Impact Test: Trials | 100°C 9.19 3.7 | |
| . % | *Average value of 5 gm sample twice lized from isoamyl alcohol. | recryster |
| Explosions | • • • • • | |
| Partials | | |
| Burned | 200 Gram Bomb Sand Test: | |
| Unaffected | Sarid, gm 59+2 | 54.1 |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | 0.200## |
| 1 5 220 | Mercury Fulminate Lead Azide | |
| 10 | | 0.100** |
| 15 | **Alternative initiating charges. | |
| 20 | Ballistic Mortar, % TNT: | 130 |
| | Trauzi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dent Test: | |
| | Method | |
| 100°C Heat Test: | . Condition | |
| % Loss, 1st 48 Hrs 8.79 | Confined | |
| % Loss, 2nd 48 Hrs 2.98 | Density, gm/cc | |
| Explosion in 100 Hrs None | Brisance, % TNT | |
| | Detenction Rute: | (७) |
| Fiammability Index: | Confinement | None |
| Hygroscopicity: % 30°C, 90% RH 0.02 | Condition | Cast |
| titition of the second se | Charge Diumeter, in. | 1.2 |
| Veletility: | Density, gm/cc | 1.42 |
| · | Rote, meters/second 7000 to | 7300 |

1537 at

| Cyclotrimethyler | e Trinit | crosamine |
|------------------|----------|-----------|
| | | |

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| fragmentation Test: | Skaped Charge Effectiveness, TNT == 100: | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------|--|
| 90 mm HE, M71 Projectile, Lat WC-91: Density, gm/cc Charge Wt, Ib | Gloss Cones Ster Hole Volume Hole Depth | el Cones | |
| Total No. of Fragments: For TNT | Color: | Yellow | |
| For Subject HF 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, lb Totel No. of Fragments: For TNT For Subject TE | Principel Uses: Ingredient of p | rojecti le filler | |
| | Method of Loading: Pressed or cast with added melting point depressants | | |
| | Loading Density: gra/cc | See below | |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft | Storage: | | |
| Density, gm/cc | Method | Dry | |
| Blest (Reletive to TNT); | Hazard Class (Quantity-Distance) | Class 9 | |
| Air: Peak Pressure Impulse | Compatibility Group Exudation | Group M Non e | |
| Energy Air, Confined: Impulse | Density at Various Pressures 1b/inch ² | : (b) gm/cc | |
| Under Weter: Peak Pressure Impulse Energy Uneicrevound: | 2,420 4,830 9,650 14,500 24,200 33,800 42,500 | 1.10 1.23 1.37 1.44 1.53 1.57 1.59 | |
| Peok Pressure Impuls t Energy | Heat of: Combustion, cal/gm Explosion, cal/gm Formation, cal/gm | 3158 876 -914 | |
| | · | | |

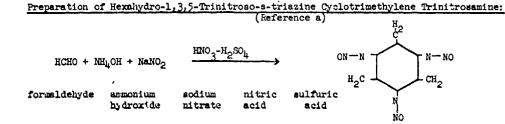
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Cyclotrimethylene Trinitrosamine



An ammoniacal solution of an amine is prepared by adding aqueous formaldehyde to ammonium hydroxide. The rate of addition of formaldehyde is regulated to maintain a solution "emperature of 30° to 35° 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 dissolving concentrated nitric acid in water and adding concentrated sulfuric acid, all chilled to $-9^{\circ}C$, there is added the cold amine-nitrite solution below the surface of the acid mixture. The addition is regulated to take 20 to 30 minutes.

The resulting foamy head of cyclotrimethylene trinitrosamine is allowed to sit over the icy spent liquor for 1/2 hour and it then collected on a sintered glass funnel and washed to neutrality. The moist cyclotrimethylene trinitrosamine is removed from the funnel and sirdried on filter paper. The dry crude product melts at 105° to 107° C. Recrystallization from isoamyl alcohol gives a pure compound melting at 105° to 107° 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 Duden and Scharff (Ann 288 (1895), p. 218) and by Delepine who determined its heat of formation, which was negative (Bull Soc chim (3) 15 (1896), p. 1199). Because cyclotrimethylene trinitrosamine could be made at first in very poor yield only, it was a long time bifort is 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,"

Destruction by Chemical Decomposition:

A STATE THE R. S. P. LEWIS CO., LANSING MICH. IN CO., LANSING MICH. & CO., LANSING MICH.

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

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Cyclotrimethylene Trinitrosamine

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

| | Immersed 10 minutes in bath | heated at 50/minute |
|-----|-----------------------------|---------------------|
| | | Temp. C |
| (1) | Melting begins | 105 |
| | Decomposition begins | 150 |
| | Nitrous gas | 160 |
| | Entire decomposition | 170 |
| (2) | Some bubbles | 110 |
| • • | Very slow decomposition | . 150 |
| | Decomposes in 2 minutes | 200 |
| | Decomposes in 40 seconds | 250 |
| | Inmediate decomposition | 300 |

Long Term Stability: (b)

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

- 1. Explosive showed no color change.
- 2. Melting point decreased from 104.5° to 104°C.
- 3. Coefficient of "Utilisation Practique" decreased from 125.5 to 123.5.
- 4. An Abel Test at 110°C gave no color to iodine starch paper in 15 minutes.

Fasion Tests, Mixtures of Cyclotrimethylene Trinitrosemine and TNT: (b)

| yclotrimethylene rinitrosamine, 🎽 | Melting Point, C |
|--------------------------------------|---------------------------|
| 10 | 74 |
| 20 | 68 |
| 3C | 62 |
| 40 | : 55 |
| 42 | 55 (Eutectic) |
| 50 | 55 55 (Butectic) 61 |
| 60 | 69 |
| 70 | 77 |
| 95 | 95 |

Eutectic Composition With TNT: (b) 42% Cyclotrimethylene Trinitrosamike 58% TNT

Timorie a W

Rate of Detonation, meters/second

7,000

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Cyclotrimethylene Trinitrosamine

Reaction of Cyclotrimethylene Trinitrosamine With Other Materials: (b)

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

Detonation Rate: (b)

| Confinement | Paper cartridge |
|------------------------------|------------------------------|
| Condition | Pressed |
| Charge Diameter, in. | 1.18 |
| Rate, meters/second | Density, gm/cc |
| 5180 5760 6600 7330 | 0.85 1.00 1.20 1.40 |
| 7600 7800 | 1.50 |

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 Le Cyclotriméthyléne 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 Cyclotrimethylene Trinitrosamine: 1174, 2179.

16See footnote 1, page 10.

DBX (Depth Bomb Explosive)

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| Composition; % | | Molecular Weight: | 83 |
|-----------------------------------------------------|----------|--------------------------------------|--------------------------------------------|
| Ammonium Nitrate | 21 | Oxygen Balance: CO ₂ % | -46 |
| RDX | 21 | CO % | -26 |
| INT | 40 | Density; gm/cc Cast | 1.68 |
| Aluminum | 18 | Melting Point: *C | |
| C/H Rotio | | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: | | Boiling Point; *C | • |
| Bureau of Mines Apparatus, cm | 35 | Budana Alua Jandara ID | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. | 13 | Refractive Index, no | |
| Sample Wt, mg | <u> </u> | n <mark>u</mark> | |
| · · · · | | n | |
| Friction Pendulum Test: | | Vecuum Stability Test: | |
| Steel Shoe | | cc/40 Hrs, at | |
| Fiber Shoe | | 90°C | |
| Rifle Bullet Impact Test: Trials | | 100°C | |
| • | | 120°C | 6.15 |
| % Explosions | | 135°C | |
| Partials | | 150°C | |
| Burned | | | ب محمد و حقوق مقاد و بنگ م در ایند که در ا |
| | | 200 Gram #omb Sand Test: | r() - |
| Unoffected | | Sond, gm | 58.5 |
| Explosion Temperature: *C | | . Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, | gm |
| 1 | | Mercury Fulminate | |
| 5 Ignites 400 |) | Leod Azide | 0.20 |
| 10 | | Tetryl | 0.10 |
| 15 | | | |
| 20 | | Bellistic Morter, % TNT: (a |) 146 |
| 75°C International Heat Test: | | Treuzi Test, % TNT: | |
| % Loss in 48 Hrs | | Plate Dent Test: (b | • |
| | | Method | B |
| 100°C Heet Test: | | Condition | Cast |
| % Loss, 1st 48 Hrs | | Confined | No |
| % Loss, 2nd 48 Hrs | | Density, gm/cc | 1.76 |
| Explosion in 100 Hrs | | Brisance, % TNT | 102 |
| | | Detanation Rate: (c |) |
| Flammability Index: | | Confinement | None |
| | | Condition | Cast |
| Hygroscepicity: % | | Charge Diameter, in. | 1.6 |
| | | Density, gm/cc | 1.65 |
| Volatility: | | | |

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DBX (Depth Bomb Explosive)

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| Booster Sensitivity Test: | (e) | Decomposition Equation: |
|------------------------------------------------|-------------------------|---------------------------------------------------|
| Londition | Cast | Oxygen, atoms/sec |
| Tetryi, am | 100 | (1./sec) |
| | 1.35 | Heat, kilocolorie/mole |
| Wax, in. for 50% Detonation | 1.37 | (JH, kcol/mol) |
| Wax, gm | | Temperature Range, °C |
| Density, gm/cc | 1.76 | Phase |
| - | | _ |
| Heat of: | (d) | |
| Combustion, col/gm | | Armor Plate Impact Test: |
| Explosion, cal/gm | 1700 | |
| | _, | 60 mm Mortar Projectile: |
| Gas Volume, cc/gm | | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | | Aluminum Fineness |
| Fusion, col/gm | | |
| | | 500-lb General Purpose Bombs: |
| Specific Heast cal/gm/*C | (d) | |
| -5°C, density 1.75 gm/cc | 0.25 | Plate Thickness, inches |
| , ., | , | |
| | | 1 |
| | | 14 |
| | | |
| | | 11/2 |
| | | - 1% |
| Burning Rate: | | |
| cm/sec | | Somb Drop Test: |
| | | |
| Thermal Conductivity: | _4 | T7, 2000-16 Semi-Armor-Piercing Somb vs Concrete: |
| col/sec/cm/*C | 13.2×10^{-4} | 17, Adde-in Semi-Almonthereing some 17 Concisio. |
| Density 1.75 gm/cc | | - Mar fate Durn fit |
| Coefficient of Expension: | 6 | Max Safe Drop, ft |
| Linear, %/°C -73°-75°C | 4.5 x 10 ⁻⁵ | 500-lb Generel Purpose Bomb vs Concrete: |
| | | |
| Volume, %/*C | | Height, ft |
| | | Trials |
| Hardness, Mohs' Scale: | | |
| | | Unaffected |
| Young's Modulus: | (a) | Low Order |
| • | 10.4 x 10 ¹⁰ | High Order |
| E', dynes/cm² | 10.4 x 10 | |
| E, Ib/inch² | 1.51 x 10 ⁶ | 1000-lb General Purpose Bomb vs Concrete: |
| Density, gm/cc | 1.72 | |
| | | Height, ft |
| Compressive Strength: Ib/inch ² (d) | 3210-3380 | Triais |
| • | <i>-</i> | |
| Density 1.78 gm/cc | | Unaffected |
| Vapor Pressure: | | Low Order |
| *C mm Mercury | | High Order |
| | | |
| • | | |
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DBX (Depth Bomb Explosive)

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| Fragmentation Test: | | Shaped Charge Effectiveness, $TNT = 100$: | | |
|--------------------------------------|-----------|----------------------------------------------------------------|-------------------|--|
| 90 mm HE, M71 Projectile, Lo | ł WC-91: | Glass Cones Steel | Cones | |
| Density, gm/cc | | Hole Volume | | |
| Charge Wt, Ib | | Hole Depth | | |
| Torel No. of Fregments: | | Celer: | Grey | |
| For TNT | | | ure) | |
| For Subject HE | | Principal Usos: | Depth charge | |
| 3 inch HE, M42A1 Projectile, L | Lot KC-3: | • | | |
| Density, gm/cc | | | | |
| Charge Wt, Ib | | | | |
| Total No. of Fragments: | | Method of Looding: | Cast | |
| For TNT | | | •••• | |
| For Subject HE | | Leading Density: gm/cc | 1.61-1.69 | |
| Fregmant Velecity: ft/sec At 9 ft | | | | |
| At 251/2 ft | | Storage: | | |
| Density, gm/cc | | Method | Dry | |
| Blast (Relative to TNT): | (d) | Hazard Class (Quantity-Distance) | Class 9 | |
| Airs | | Compatibility Group | Group I | |
| Peak Pressure | 118 | | | |
| Impulse | 127 | Exudation | | |
| Energy | 138 | | | |
| Air, Conficad: | | Preparation: | | |
| Impulse | | DBX can be manufactured by | slowly adding | |
| | | water-wet RDX to molten TNT m | elted in a steam- | |
| Under Weter: Peak Pressure | | jacketed kettle equipped with | | |
| Impulse | | all the water has evaporated, is added and with heating and | | |
| Chergy | 136 | tinued, grained aluminum is a ture is cooled with stirring | dded. The mix- | |
| Underground: | | maintain uniformity and when | | |
| Peak Pressure | | ing the mixture is cast. DBX by adding 21% ammonium nitrate | | |
| Impulse | | num to 42% cyclotol or Compos | ition B of 50/50 | |
| Energy | | RDX/TNT content plus 19% of T melted at about 100°C. | NT previously | |
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DBX (Depth Bomb Explosive)

Origin:

. DEX was developed and used by the United States and Great Britain during World War II.

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References: 17

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

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

(d) Philip C. Keenan and Dorothy Pipes, <u>Table of Military High Explosives</u>, Second Revision, NAVORD 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 Technica. Reports on DBX: 1585 and 1635.

17See footnote 1, page 10,

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

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| Composition: % NK | | Molecular Weight: (C6H5N5 | 06) | 243 |
|---------------------------------------------------|------------------|----------------------------|---------|---------|
| % NH C 29.6 1 | 2 | Oxygen Balance: | | |
| H 2.1 02N | T NO2 | CO. % CO % | | |
| N 28.8 | L _{NH2} | Density: gm/cc | Crystal | 1.83 |
| 0 39.5 NO | 2 | Melting Point: "C | (a) | 290 |
| C/H Ratio 0.380 | | Freezing Point; *C | | |
| Impact Sensitivity, 2 Kg Wt: | | Boiling Point: *C | | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | | Refrective Index, no | | |
| Picatinny Arsenal Apparatus, in. | 18 | ns | | |
| Sample Wt, mg | 9 | n ₂₀ | | |
| Friction Pendulum Test: | | Vecuum Stebility Test: | | |
| Steel Shoe | | cc/40 Hrs, at | | |
| Fiber Shoe | | 90°C | | |
| Rifle Bullet Impact Test: Trials | | 100.0 | | |
| % | | 120.0 | | |
| Explosions | | 135*C | | |
| Partials | | 150°C | | |
| Burned | | 200 Gram Bomb Sand Test: | | |
| Unaffected | | Sand, gm | | 46.6 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charg | ge, gm | |
| 1 5 | | Mercury Fulminate | | |
| 10 | | Leod Azide | | 0.50 |
| 15 | | Tetryl | | 0.10 |
| 20 | | Bailistic Mortor, % TNT: | | 100 |
| | | Trouxi Test, % TNT: | | |
| 75°C International Heat Test: % Loss in 48 Hrs | | Flote Dent Test: | | |
| · | | Method | | |
| 100°C Hest Test: | | Condition | | |
| % Loss, 1st 48 Hrs | 0.00 | Confined | | |
| % Loss, 2nd 48 Hrs | 0.4 | Density, gm/cc | | |
| Explosion in 100 Hrs | tione | Brisance, % TNT | | |
| P1 | | Detenation Rate: | | |
| Flemmebility Index: | | Confinement | | None |
| Hygroscopicity: % | | Condition | | Pressed |
| III BIASCANICUT: 20 | | Charge Diameter, in. | | 0.5 |
| Velatility: | | Density, gm/cc | | 1.65 |
| · | | Rate, meters/second | ÷ | 7500 |

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

| Fragmentation Test: | Shaped Charge Effectiveness, $TNT = 100$: | | |
|----------------------------------------|--------------------------------------------|----------|--|
| 90 mm HE, M71 Projectile, Lot WC-91: | Glass Cones Stee | l Cones | |
| Density, gm/cc | Hole Volume | | |
| Charge Wt, Ib | Hole Depth | | |
| Total No. of Fragments; | Celor: | Yellow | |
| For TNT | | | |
| For Subject HE | Principal Uses: | | |
| 3 inch HE, M42A1 Projectile, Lot &C-3: | | | |
| Density, gm/cc | | | |
| Charge Wt, Ib | | | |
| Total No. of Fragments: | Alethed of Loeding: | Pressed | |
| For TNT | | 1100000 | |
| For Subject HE | | | |
| | Leeding Density: gm/cc At 50,000 psi | 1.65 | |
| Fragment Velocity: ft/sec At 9 ft | | | |
| At 251/2 ft | Storage: | | |
| Density, gm/cc | Method | Dry | |
| | | | |
| Biest (Relative to TNT); | Hazard Class (Quantity-Distance) | | |
| Air: | Compatibility Group | | |
| Peak Pressure | | | |
| Impulse | Exudation | None | |
| Energy | | | |
| Air, Confine 1: | Cook-Off Temperature: °C | 320 8 | |
| Impuls | Time, minutes | 0 | |
| Under Water: | Heat of: | | |
| Peak Pressure | Explosion, cal/gm | 2876 | |
| Impulse | | | |
| Energy | | | |
| Underground: Peak Pressure | | | |
| Impulse | | | |
| Energy | | | |
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1, 3-Diamino-2, 4, 6-Trinitrobenzene (DATNB)

AMCP 706-177

Preparation:

Fifty grams (50 gm) of dry stypnnic 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°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 litemus. 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 ammonis 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 washings. Yield of 1,3-diamino-2,4,6-trinitrobenze. -2.5 gm (97%), MP 288° to 290°C (literature MP 285°C).

Origin:

DATNB, 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 <u>17</u>, 260) and also by Barr in 1888 (Ber <u>21</u>, 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 <u>21</u>, 324) and from 2,4,6-trinitroresorcin methylethyl ether with ammoniscal alcohol (Rec trav chim <u>27</u>, 56 (1908)).

Meisenheimer and Patzig in 1906 prepared DATNB in the form of yellow needles, MP 280° C from 1,3,5-trinitrobenzene hydroxylamine 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 NH₃ and 2,4,6-trinitroresorcin when boiled with dilute NaCH or KOH (5eil 13, 60).

Körner and Contardi prepared DATNB by the reaction of either 2,4-dichloro-1,3,5-trinitrobenzene or 2,4-dibromo-1,3,5-trinitrobenzene with ammoniacal alcohol at room temperature or better by heating to 10C 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 anmonia solution was reported in 1913 by van Romburgh and Schepers (Akad Amsterdam Versl <u>22</u>, 297).

C. F. Van Duin obtained LATNE 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-trinitrophenylene/iamine-(1,3) (Rec trav chim 38, 89-100 (1919)). Later Van Duin and Van Lennep reacted concentrated aqueous ammonia with 2,4,6-trinitro-3aminoenisole or 2,4,6-trinitro-3-aminophenetol to obtain DATNE melting at 287° to 288°C (Rec trav chim 39, 147-77 (1920)). In 1927 Lorang prepared the same compound by boiling 2,4,6trinitro-1,3-bis (-nitroethyl ureido) benzene with water or by heating it with ammoniacel alcohol in a tube at 100°C (Re: trav chim $\frac{46}{26}$, 649) (Beil E 17, E II 33).

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2., 3-Diamino-2, 4, 6-Trinitrobenzene (DATMB)

A recent report describes the preparation of DATNB in two steps from commercially available starting materials. First m-nitroaniline was nitrated with H₂SO₄-HNO₃ acid mixture to tetranitroaniline. The crude tetranitroaniline was converted by methanolic summonia to diaminotrinitro-benzene in a high degree of purity. A conversion of 100 parts of m-nitroaniline into 110 parts of DATNB was obtained by this method, which can easily be carried out on a commercial scale. ------

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Diszodinitrophenol

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AECP 706-177

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| Composition: % | N | Melecular Weight: (CGH2N405) | 210 |
|----------------------------------------------------------------------------|------------------|----------------------------------------------------|------------|
| с 34.3 И ого ого | İ. | Oxygen Belance: CO ₂ % (.0 % | -61 -15 |
| N 26.7 02N NO2 02N | Y NO2 | Dunsity: gm/cc Crystal | 1.63 |
| 0 38.1 | ō | Making Point: "C | 157 |
| C/H Ratio 1.056 | | Freesing Points "C | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mirles Apparatus, cm | | Bailing Joint: *C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 4; (1 Sample Wt, mg | 1 16 wt) 7 15 | Refrective Index, nº , nº nº | |
| Friction Pandulum Test: | | Vecuura Stebility Test: | |
| | etonates | cc/40 Hrs, at | |
| Fiber Shoe De | etonates | 90°C | 7.6 |
| Rifle Builet Impact Test: Trials | | - 100°C 120°C | (.0 |
| 16 | | 135°C | |
| Explosions | | 150°C | |
| Partials | | | |
| Burned | | 200 Grom Bemb Sand Test: | 47.5 |
| Unoffected | | Bit the powder fuse | 47.5 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cop used) i 200 | | Minimum Detonating Charge, ym Mercury Fulminate | |
| 5 195 | | Leod Azide | 0.20 |
| 10 180 | | Tetryl | 0.10 |
| 15 | | | ~~~~~ |
| 20 | | Bellistic Morter, % TNT: (a) | 97 |
| 73°C International Heat Tast: | | Traual Test, % TNT: | |
| 96 Loss in 48 Hrs | | Plate Dent Test: Method | |
| 100°C Heat Test: | | Condition | |
| Su Loss, 1st 48 Hrs 2. | . 10 | Confined | |
| % Loss, 2nd 48 Hrs 2. | . 20 | Density, 5m/cc | |
| Explosion in 100 Hrs No | one | Brisonce, % TNT | |
| Flammability Index: | | - Datanation Rate: Confinement | manaal |
| Hygrescepicity: % 30°C, 90% RH 0. | .04 | - Condition E Charge Diameter, in. | Pressed |
| | | - Density, gm/cc 0.9 | 1.5 1.6 |

*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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AMCP 706-177

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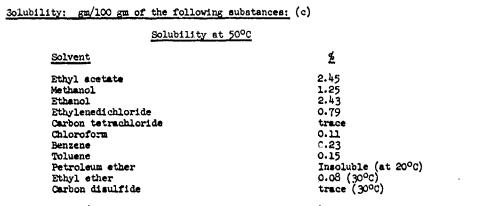
Diazodini trophenol

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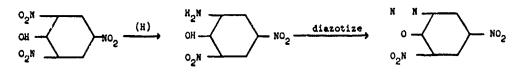
| Fregmentation Test: | Shaped Charge Effectivaness, TNT = | = 100: | |
|----------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|--|
| 90 mm HE, M71 Projectile, Le: 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, Lot KC-3: Density, gm/cc | | ellow needles | |
| Charge Wt, Ib Tatel No. of Fragments: For TNT For Subject HE | Method of Londiny: | Presued | |
| Fregment Vulocity: ft/sec At 9 ft At 251/2 ft | Leading Donsity: gm/cc Appm.cent 0.27 At 3000 pei 1.14 Storoge: | | |
| Density, gm/cc | Method Hazard Class (Quantity-Distance) | Under water Class 9 | |
| Air: Air: Peak Pressure Impulse Energy | Compatibility Group Exudation | None | |
| Air, Centineel: Impulse Under Weter: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse Energy | Solubility: Soluble in nitroglycerin aniline, pyridine, concentration, pyridine, concentration, and in most common or Reat of: Combustion, cel/gm Explosion, cel/gm Ges Volume, cc/gm Sensitivity to Electrostation Diucharge, Joules: | ated hydrochloric mic solvents. 3243 820 865 | |
| | | | |

Diazodinitrophenol

AMCP 706-177



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 sodium nitrite in 10 cc water is dumped into the suspension. Stirring is continued for 20 minutes, the product filtered off and washed thoroughly with icc water. The dark brown product, if dissolved in acetone and precipitated in water, turns brilliant yellow.

Origin:

Discovered by Griess in 1858 (Annalen <u>106</u>, 123; <u>113</u>, 205 (1860) and studied extensively by L. V. Clark (Ind Eng Chem <u>25</u>, 663 (1933). Developed for commercial use in 1928. This compound was patented in the United States by Professor William M. Dane.

Destruction by Chemical Decomposition:

Diazodinitrophenol is decomposed by adding the water-wat material to 100 times its weight of 10% sodium hydroxide. Nitrogen gas is evolved.

References: 18

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

(b) F. W. Brown, D. H. Kusler and F. C. Gibson, Sensitivity of Explosives to Initiation by

¹⁸Sue footnote 1, page 10.

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Diszodinitrophenol

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

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

Seidell, Solubilities of Inorganic and Organic Compounds, Van Nostrand and Co., N. Y.

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

| <u>o</u> | 2 | 4 | ٤ | I | 8 | 2 |
|--------------------|------|-----------|-----|-----|----------------------|------|
| 150 610 2120 | 1352 | 34 214 | 355 | 827 | 318 18 3 8 | 2179 |

Disthylens Glycol Dinitrate (DEGN) Liquid

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| Composition: | Melocular Weight: (C4H8N207) | 196 |
|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|---------------|
| c 24.5 H_2c oNo_2 | Oxygen Belanza; CO: % CO % | -41 - 8 |
| $\frac{1}{N}$ 14.3 $\frac{1}{N_{2}C} > 0$ | Density: gm/cc Liquid | 1.38 |
| $0 57.1 H_2^{-1} - 0 00_2$ | Maiting Point: *C | 2 |
| C/H Ratio 0.143 | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: | Beiling Peint: *C Decomposes | 160 |
| Bureau of Mines Apparatus, cm 100+ Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 9 Sample Wt, mg | Refrective Index, ng ng ng | 1.4498 |
| Friction Pandulum Tast: | Vacuum Stability Test: | ····· |
| Steel Shoe Explud Fiber Shoe | es cc/40 Hrs, at 90°C | 0.00000-1-1- |
| Rifle Buildt Impact Test: Triais % | 100°C 120°C 135°C | 0.3ce/20 hr/g |
| Explosions | 150°C | |
| Partials Burned | 200 Green Bemb Send Test | |
| Unaffected | Sand, gm | 42.2 |
| Explosion Temperature: *C Seconds, 0.1 (no cop used) 1 5 237 10 15 | Sensitivity to Initiation: Minimum Detanating Charge, gm Mercury Fulminate Lead Azide Tetryl | ' |
| 20 | Ballistic Mortar, % TNT: | 90 |
| | Trouzi Yest, % Ti4T: | 77 |
| 75°C International Heat Tast: % Loss in 48 Hrs | Pleta Dent Test: Method | |
| 100°C Heat Test: | Condition Confined | |
| % Loss, 1st 48 Hrs 4.0 % Loss, 2nd 48 Hrs 3.0 | Density, gm/cc | |
| % Loss, 2nd 48 Hrs 3.0 Explosion in 100 Hrs None | Brisance, % TNT | |
| Flammability Index: | Datenation Rate: Confinement | |
| Hygroscopicity: % | Condition Charge Diameter, in. | |
| Veletility: 60°C, mg/cm ² /hr 193 | Density, gm/cr Rate, meters/second | 1.38 6760 |

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Diethylene Glycol Dinitrate (DEGN) Liquid

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| Beaster Sensitivity Test: Condition Tetryl, cm Wax, m. for 50% Detonation Wax, gm Density, gm/cc | Decomposition Equation: Oxygen, atoms/sec (Z/sec) Heat, kilocalorie/male (ΔH, kcal/mol) Temperature Range, *C Phase |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Hiset of: Combustion, cal/gm Explosion, cal/gm Gas Volume, cc/gm Formation, cal/gm Fusion, cal/gm Specific Heet: cal/gm/*C Specific Heet: cal/gm/*C Specific Heet: cal/gm/*C Then al Conductivity: cal/sec/cm/*C Coefficient of Expansion: Linear, %/*C Volume, %/*C Volume, %/*C Hardness, Mohs' Scele: Young's Modulus: E', dynes/cm ² E, ib/inch ³ Density, gm/cc Compressive Strength: Ib/inch ⁴ Yeper Pressure: *C mm Mercury 20 0.0036 60 0.130 | 2792 Armer Plete Impect Test: 841 50 mm Marter Projectile: 796 50% inert, Velocity, fr/sec 2020 Aluminum Fineness 300-lb General Purpece Bomba: Plate Thickness, inches 1 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ 1½ |
| | |

Diethylene Glycol Dinitrate (DEGN) Liquid

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| Fregmantation Text: | Shaped Charge Effectiveness, TNT = 100: |
|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, lb | Glass Cones Steel Cones Hole Volume Hole Depth |
| Total Na. of Fragmants: Far TNT | Colorless |
| For Subject HE 3 inch HE, M42A1 Projectile, Let KC-3: Density, gm/cc Charge Wt, ib | Frincipal Uses: Propellant compositions |
| Total No. of Fragments: For TNT | Mothod of Loading: |
| For Subject HE Fregmant Velecity: ft/sec | Looding Dessity: gm/cc |
| At 9 ft At 25% ft | Storage: |
| Density, gm/cc | Method Liquid |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) Class 9 |
| Air: Peak Pressure impuise Energy | Compatibility Group Exudation |
| Air, Confined: Impulse Under Water: Peak Pressure Impulse | Preparation: DBDN can be prepared with approxi- mately 85% yield by adding diethyleneglycol to mixed acid (50% HNO ₃ , 45% H ₂ SO _b , and 5% H ₂ O). The temperature is kept at 30°C or lower. The separated DBDN is purified by washing with successive portions of water, dilute acdium carbonate solution and water until neutral. |
| Energy Underground: Peak Pressure Impulse Energy | Hydrolysis, % Acid: 0.003 10 days at 22°C 0.003 5 days at 60°C 0.003 Solubility in Water, gm/100 gm, at: 25°C 60°C 0.60 |
| Viscosity, centipoises: Temp, 20 ⁰ C 8.1 | Solubility, gm/100 gm, at 25°C, in:Ether00Alcohol002:1 Ether:Alcohol00Acetone00 |

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Diethylene Glycol Dinitrate (DECN) Liquid

Origin:

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First prepared and studied by Wm. H. Rinkenbach in 1927 (Ind Eng Chem 19, 925 (1927) and later by Rinkenbach and H. A. Aaronson (Iri Eng Chem 23, 160 (1931)) both of Picatinny Arsenal. Used in propellant compositions by the Germans during World War II.

Destruction by Chemical Decomposition:

LEON is decomposed by adding it slowly to 10 times its weight of 18% sodium sulfide (Na₂S^o9H₂O). Heat is liberated by this reaction but this is not hazardous if stirring is maintained during the addition of DEGN and continued until solution is complete.

keferences: 19

Sec ...e following Picatinny Arsensl Technical Reports on DEGN:

| <u>0</u> | <u>1</u> | · <u>2</u> | <u>3</u> | 4 | · <u>6</u> | ĩ | 2 |
|----------------------------------|----------------------------|---------------------------|-------------|-------------|-----------------------------|-----------------------------|--------------------|
| 50 180 620 1490 1990 | 231 551 1391 1421 | 72 602 1282 1392 | 673 1443 | հ94 16⊋4 | 346 1516 1616 1786 | 487 1427 1487 1817 | 279 579 1439 |

¹⁹See footnote 1, page 10.

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Bis(2,2-Dinitropropyl) Fumerate (DNPF)

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AMCP 706-177

| Composition: | Moleculer Weight: (C ₁₀ H ₁₂ N ₄ 0 ₁₂) | 380 |
|--------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|--------------|
| с 31.6 снсо₂сн₂с(№ ₂)₂сн ₃ н 3.2 | Oxygen Belence: CO3 % CO % | -59 -17 |
| и 14.7 сноо2сн2с(NO2)2сн3 | Density: gm/cc Crystal | 1.60 |
| 0 50.5 | Melting Point: "C Form I Form II | 89 86 |
| C/H Ratio | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 100+ Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 18 Sample Wt, mg 18 | Boiling Point: *C Refrective Index, nm nm nm | |
| Friction Pendulum Test: | Vacuum Stability Test; | |
| Steel Shoe Unaffected Fiber Shoe Unaffected | cc/40 Hrs, at 90°C | 0.66 |
| Rifle Builet Impact Test: Trials | | |
| % Explosions Partials | 135°C 150°C | 0.91 |
| Burned Unaffected | 200 Grem Bamb Sand Test: Sand, gm | |
| Caspiesten Tempereture: *C Seconds, 0.1 (no cop used) 1 4 Saukes 10 15 20 | Sansitivity to Initiation: Mir.: Tem Detonoting Charge, gm Mercury Fulminate Lead Azide Tetryi Bellistic Mariner, % TNT: | |
| | | |
| 75°G International Heat Test: % Loss in 43 Hrs | Plute Dent Test: Mathod | |
| 100°C Heat Test: | Condition Confined | |
| % Loss, 1st 48 Hrs % Loss, 1st 48 Hrs | Density, gm/cc | |
| 96: Lees, 2nd 48 Hrs Explosion in 100 Hrs | Brisance, % TNT | |
| Flammobility Index: | - Detenation Rate: Conflacment | |
| Hygroscopicky: % | Condition Charge Diometer, in, | |
| Voletility: | Bensity, gm/cc Rute, metc s/second | 1.49 6050 |

ŧ AMCP 706-177 Bis(2,2.Dinitropropyl) Fumerate (DNPF) Shaped Charge Effectiveness, TNT == 100: Fragmontation Test: 90 mm HE, M71 Projectile, Lot WC-91: Gloss Cones Steel Cones Density, gm/cc Hole Volume Charge Wt, Ib Hole Depth **Total No. of Fragments:** Color: White For TNT For Subject HE **Principal Uses:** 3 Inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib Total No. of Fragments: Method of Loading: Cast For TNT For Subject HE Looding Density: gm/cc 1.50 Fregment Valocity: ft/sec At 9 ft At 251/2 ft Storuge: Density, gm/cc Method Dry Sisst (Relative to TMT); Hazard Class (Quantity-Distance) Compatibility Group Air: Peak Pressure None Exudation Impulse Energy Heat of: Air, Conflored: Combustion, cel/gm 3070 Impulse (calculated) Detonation, cal/gm 767 Under Water: (calculated) Peak Pressure Viscosity, poises: Impulse Temp, 98.9°C 106.5°C 0.586 0.435 Energy Liquid Density, gm/cc: Underground: Peak Prassura Temp, 98.9°C 106.5°C 1.382 1.375 Impulse Emergy Origin: Synthesized in 1952 by M. E. Hill of the U.S. Naval Ordnance Laboratory, White (ey, Maryland.

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Bis(2,2-Dinitropropyl) Fumerate (INPF)

Preparation:

(a, b)

 $\begin{array}{cccc} HC-COCl & HC-CO_2CH_2C(NO_2)_2CH_3 \\ \parallel & + 2CH_3C(NO_2)_2CH_2OH & AlCl_3 & \parallel \\ HC-COCl & & HC-CO_2CH_2C(NO_2)_2CH_3 \\ \hline & & & & \\ 3.3 \ \text{mol} & 7.3 \ \text{mol} & 1.6 \ \text{mol} & 83\% \ \text{yield} \\ \hline & & & & \\ fummaryl \ chloride \ 2,2-dinitropropenol \ aluminum \ bis(dinitropropyl) \ fumarate \\ chloride \end{array}$

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 bucket. As cooling took place the slurry was vigorously agitsted until it finally set up at room temperature. This material was broken up and mixed with dilute ice cold HCl. The solid product was collected on a sintered funnel, washed with water and with hexane. The crude material was recrystallized from methanol to give a product melting at 86°C (uncorrected), but after storage for several days the melting point was 89°C.

References; 20

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

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

²⁰See footnote 1, page 10.

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AHCP 706-177

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Bis(2,2-Dinitropropyl) Succinste (DNPS)

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| Composition: % | Molecular Weight: $(C_{10}H_{14}N_{4}O_{12})$ | 382 | | |
|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------------|--|--|
| С 31.4 н 3.7 | Oxygen Belence; CO3 % CO % | -63 -21 | | |
| N 14.7 | Density: Jm/.: Crys.cs1 | 1.51 | | |
| ೦ 50.2 ದ್ವಾಲ್ಮಾದರ್ಗಿಂಗಿರೆ) ವಿದ್ವ | Maiting Point: "C | 86 | | |
| C/H Ratio 0.250 | Frenzing Paint: "C | | | |
| Impact Sansitivity, 2 Kg Wt: | Beiling Fuint: *C | | | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg | Refractive Jdez, ng ng ng | | | |
| Friction Pandulum Test: Steel Shoe | Vecture Stubility Test: cc/40 Hrs, at 90°C | | | |
| Fiber Shoe Rifle Bullet Impact Test: Triais % Explosions Partials | 100°C 120°C 135°C 150°C | 0.10 | | |
| Burned Unaffected | 200 Gram Bomb Sand Test: - Sond, gm | | | |
| Explosion Temperature: *C Seconds, 0.1 (no cop used) 1 5 >400 10 | Sensitivity te Initiation: Minimum Detonating Charge, gm Mercury Fulminate Leod Azide Tetryi | | | |
| 20 | Ballistic Mortur, % TNT: | | | |
| 75°C International Heat Test: % Loss in 48 Hrs 100°C Heat Test: | Trauzi Test, % TNT: Plate Dant Test: Method Condition | | | |
| % Loss, 1st 48 Hrs | Confined | | | |
| % Loss, 2nd 48 Hrs | Density, gm/cc Brisance, % TNT | | | |
| Explosion in 100 Hrs | | | | |
| Flammability Index: | Detenation Rate: Confinement | | | |
| Hygroscopicity: % | Condition Charge Diameter, in. | | | |
| Veletility: | Density, gm/cc Rate, meters/second | | | |

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

AMCP 706-177

| Fregmentation Test: | Shaped Charge Effectiveness, TNT = '100: |
|--------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
| 90 mm HE, /471 Projectile, Let WC-91: Density, gm/cc Cwarge Wt, Ib | Glass Cones – Steril Cones Hole Volume Hole Depth |
| Total No. e/ Fragments: For T NT | Color: White |
| For Subject HE | Principal Uses: |
| 3 isch HE, M42A1 Prejectile, Let KC-5: Density, gm/cc | |
| Charge Wt, Ib | |
| Total No. of Fregments: For TNT | Mothod of Londing: Cast |
| For Subject HE | Looding Density: gm/cc |
| Fregment Velocity: ft/sec | |
| At 25½ ft Density, gm/cc | Storego: Method Day |
| Slast (Roletive to TNT): | Hazard Class (Quantity-Distance) |
| Air: Peol: Pressure | Compatibility Group |
| Impulse | Exudation None |
| Energy | |
| Air, Confined: | <u>Origin:</u> |
| Under Weter: Peak Pressure | Synthesized in 1953 by M. E. Hill of the U.S. Havel Ordnance Laboratory, White Oak, Maryland. |
| Impulse Energy | |
| Underground: Peak Pressure | |
| Impulse | |
| Energy | |
| | |
| | |

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| AMCP 706-177 | <u>Bis(2</u> | 2-Dinitropro | opyl) Succinate (DNPS) |
|---------------------------------------------------------|------------------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Preparation: | | (4) | |
| 5сн ³ с(10 ⁵)5сн ⁵ он | + Sil ₂ COC1 | AlCl ₃ | сн ₂ соосн ₂ с(No ₂) ₂ сн ₃ + 2нс). Сн ₂ соосн ₂ с(No ₂) ₂ сн ₃ |
| dini tropropenol | succinyl chloride | aluminum chloride | bis(2,2-dinitropropyl) succinste |

A methylene chloride solution of dinitropropanol (0.02 mol in 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 DNPS (melting point 85° to 85.6°C).

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References: 21

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

²¹See footnote 1, page 10.

2,2-Dinitropropyl-4,4,4-Trinit: obutyrate (DNPTB)

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| Composition: % | Molecular Weight: (C7H9N5012) 355 | |
|-------------------------------------------------------------------------|----------------------------------------------------|----|
| c 23.6 | Oxygen Belance: CO ₂ % -29 | |
| H 2.5 OCH ₂ C(NO ₂) ₂ CH ₃ | CO % +2.3 | |
| N 19.7 C | Density: gm/cc Crystal 1.6 | 8 |
| 0 54.2 CH2CH2C(NO3) | Melting Point: 'C Form I 11 Form II Form III 59 | 95 |
| C/H Ratio | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: | Builing Paint: *C | |
| Bureau of Mines Apparotus, cm Somple Wt 20 mg | Refrective Index, nº | |
| Picatinny Arsenai Apparatus, in. | n | |
| Somple Wt, mg | n _m | |
| Friction Pendulum Test: | Vacuum Stability Test; | |
| Steel Shoe | cc/40 Hrs, ot | • |
| Fiber Shoe | 90'C | |
| Rifle Bullet Impact Yest: Trials | 100°C 0.5 | |
| · % | 120°C 135°C | |
| Explosions | 150°C | |
| Partials | 130 € | |
| Burned | 2^0 Gram Romb Sond Test: | |
| Unaffected | Sand, gm | |
| Rxplotion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | |
| 1 5 300 | Mercury Fulminate | |
| 10 | Lead Azide | |
| 15 | Tetryi | |
| 20 | Ballistic Moriur, % TPIT: | _ |
| | Truuzî Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dent Test: | |
| | Method | |
| 100°C Heet Test: | Condition | |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | |
| Explosion in 100 Hrs | Brisance, % TNT | |
| Flemmability Index: | Detenative Rete: Confinement | |
| | Condition | |
| Hygroscopicity: % | Charge Diameter, in. | |
| | Density, gm/cc 1.6 | 7 |
| Veletility: | Rate, meters/second 760 | • |

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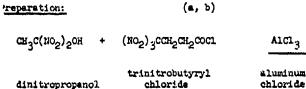
| regmentation Tost: | Shaped Charge Effectiveness, TNT = 100: |
|----------------------------------------|---------------------------------------------------------|
| 90 mm Hž, M71 Projuctile, Lot WC-91: | Girr's Cones Steel Cones |
| Density, gm/cc | Hole Volume |
| Charge Wt, Ib | Hole Depth |
| Total No. of Fragmants: | Color: Wbite |
| For TNT | |
| For Subject HE | Principal Uses: |
| 3 inch HE, M42A1 Projectile, Let KC-3: | |
| Density, gm/cc | |
| Charge Wt, Ib | |
| Total Ha. of Fragmants: | Method of Looding: Cast |
| For TNT | |
| For Subject HE | Looding Density: gm/cc 1.67 |
| ngmanî Velecity: ft/soc | |
| At 9 ft At 25½ ft | Storego: |
| Density, gm/cc | |
| • | Method Dry |
| last (Relative to THT): | Hazard Closs (Quantity-Distance) |
| Airt | Compatibility Group |
| Peak Pressure | . Exudation None |
| Impulse | |
| Energy | |
| Air, Centined: | Heat of: (c) Solvent |
| Impulse | Transition, cal/gm CCl, DMF |
| | I → III 6.2 4.8 |
| Under Weter: ' Peak Pressure : | II |
| Impulse | Heat of Solution, 30°C: |
| Energy | AH Solution, cel/gm |
| 4 - 4 4 · · · | Meterial CCl _h IMF |
| Underground: Pock Pressure | Form III 29.5 8.1 |
| Impulse | Form I 35.6 12.8 |
| Energy | Form II 19.1 -9.1 |
| | Origin: |
| : | Synchesized in 1952 by M. E. Hill of the |
| | U.S. Nevel Ordnance Laboratory, White Oak, Maryland. |

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2,2-Dinitropropy1-4,4,4-Trinitrobutyrate (DNPTB)

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dinitropropanol.

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CH3C(NO2)2CH2COOCH2C(NO2)3 ulnitropropyl trinitrobutyrate

Dinitropropanol, trinitrobutyryl chloride and aluminum chloride were slowly wixed in car-bon tetrachloride at 60° C. This mixture w refluxed at 75° C for two hours. After the reac-tion was completed, the mixture was cooled and the crystalline product separated and purified. Water in the dimitropropeno) was removed by azeotropic distillation before the acid chloride was added. The purified product had a melting point of 95° to 96°C.

+ HC1

Crystallographic Data: (c)

Three distinct crystallographic modifications of DNPTB 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, chloroformhexane, acetone-water, or methanol-water at room temperature. Prolonged standing of Form I at room temperature under the mother liquor promotes a transition to Form II. Upon solidification of molten DNPTB, Form II is always observed.

| Temperature, | Average Rate, sq inch/hour | Standard Dei lation | Average Rate, mm/hour |
|--------------|-------------------------------|------------------------|--------------------------|
| 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 |
| 35 | 0.253 | 0.037 | 0.075 |

Linear Rate of Transformation of Form II to Form I (0)

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

References 22

1

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

(b) W. B. Hewson, Hercules Report on High Explosives, Nevy Contract MOrd-11280, Teak 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 DNPTB, NAVORD Report No. 4427, 11 December 1955.

²²Set footnote 1, page 10.

| Competition: % CH ₃ | Molecular Weight: (C ₇ H ₆ N ₂ O ₄) | 1.82 |
|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|--------------|
| c 46.3 | Oxygen Balance: CO.g. % CO. % | -114 - 53 |
| H 3.3 N 15.4 | Pensity: gm/cc | 1.521 |
| | Melting Point: *C | 71 |
| C/H Rotio 0.579 | Freezing Point: "C | |
| mpect Sensitivity, 2 Kg Wt: | Boiling Point: "C Decomposes | 300 |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenai Apparatus, in. Sample Wt, mg | Refrective Index, ng ng ng | |
| Friction Pendulum Test: | Vecuum Stebility Test: | <u> </u> |
| Steel Shoe Unaffected Fiber Shoe Unaffected | cc/40 Hrs, at 90*C | |
| kifle Bullet Impect Test: Triais % | 100°C 120°C | 0.04 |
| Explosions O Partials O | 135°C 150°C | |
| Burned O | 200 Grem Bomb Sund Test: | |
| Unaffected 100 | Sand, gm | 19.3 |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) 1 | Sensitivity to Initiation: Minimum Detonating Charge, grr Mercury Fulminate | 1 |
| 5 Decomposes 310 | Leod Azide | 0.20 |
| · 15 | Tetiyi | 0.25 |
| 20 | Ballistic Mortar, % TNT: (a) | 71 |
| | Treuzi Test, % TNT: (b) | 64 |
| ^{75°} C International Heat Test; % Loss in 48 Hrs | Plate Dent Test: Method | |
| 00°C Heet Test: | Condition | • |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | |
| Explosion in 100 Hrs | Brisance, % TNT | |
| fammebility Index: | Detenstien Rete: Confinement Condition | |
| Hygrescepicity: % 25°C, 100% RH 0.00 | Condition Charge Diameter, in. | |
| | | |

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| | 2,4-Dinitrotoluene (INT) AMC | P 706-177 |
|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|--------------------|
| Fregmentation Test: | Shoped Charge Effectiveness, TNT == 160: | |
| 90 mm HE, M71 Projectile, Lot WJ-91 Density, gm/cc Charge Wt, Ib | : Glass Cones Steel Cones Hole Volume Hole Depth | |
| Y otel Ne. of Fregments; For TNT For Subject HE | Color: Yellow | |
| 3 iazh HE, M42A1 Projectile, Let & C-5; Density, gm/cc Charge Wt, ib | Principel Uses: Ingredient of propella powder, dynamites and plastic explosives | nt |
| Total No. of Fragments: For TNT | Mothed of Looding: Pressed, extruded c composition | r cast |
| For Subject HE Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Leading Density: gm/cc Varia Storage: Method Dry | ble |
| Blast (Relative Ir, TNY): | Hazard Class (Quantity-Distance) C222 | s 12 |
| Air: Peak Pressure impulse Energy | Compotibility Group Grou Exudation | p D |
| Air, Confixed: Impuise | 65.5°C KI Test: Minutes 60+ | |
| Under Weter: Peak Pressure Impulse | <u>Heat of:</u> Combustion, cal/ga (b) 1545 | i |
| Energy Underground: Paak Pressure | Thermal Conductivity: cal/sec/cm/°C Density 1.322 gm/cc 6.28 ; | < 10 ⁻⁴ |
| Impulse Energy | | |

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2,4-Dinitrotoluene (INT)

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Preparation:

See TNT.

Solubility: gm/100 gm of the following substances:

| Ethyl | 301 Alcohol | Nitro | lycerin | | Water |
|----------------|----------------------|-----------|---------|-----------------|-------------------------|
| °c | ź | <u>°C</u> | ž | <u>°c</u> | ٤ |
| 25 35 45 | 0.16 0.29 0.49 | 20 | 30 | 22 50 100 | 0.027 0.037 0.254 |
| 55 60 | 0.77 | | | | |

Solubility at 15°C, in:

| Solvent | ž | Solvent | z |
|-----------------------------|--------|---------------------------------------------|--------|
| ପାପ୍ୟ 3 | 65.076 | C _o H _c OH (absolute) | 3.039 |
| ମେଧୁ | 2.431 | Ether (absolute) | 9.422 |
| ଦେଅରୁ | 60.644 | Acreane | 81.901 |
| ଅଧାରତୀ | 45.470 | Ethyl acetate | 57.929 |
| ମଧ୍ୟରମ୍ଭ | 5.014 | CS ₂ | 2.306 |
| ଜୁଣା _ର ତାନ (୨୦%) | 1.916 | Fyridine | 76.810 |

Origin:

Occurs 44 75% of the products obtained on the nitration of toluene, the remaining 25% being mainly 2,6-DNY and other isomers of DNT. Also occurs as an impurity in crude TNT obtained by standard manufacturing process. Used in explosive mixtures at least since 1931.

References: 23

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

(b) A. H. Blatt, <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 DNT:

| <u>0</u> | 1 | 2 | 3 | <u>4</u> | ٤ | <u>6</u> | I | <u>8</u> | 2 |
|-------------|------------------------------------------------------|-----------------------------------|---------------------------------------------------------|----------------------------------------------------------------------------|--------------|-----------------------------|------------------|--------------------|----------------------------------------|
| 810 1830 | 1351 1501 1651 1781 1821 2031 2221 | 72 372 97.1 1672 1692 | 43 233 343 673 1023 1663 1743 2013 | 394 804 1044 1084 1164 1164 1524 1524 1674 1674 | 1615 2125 | 136 1556 1816 1896 | 97 817 837 | 768 938 1538 | 69 149 249 279 779 1749 |

23See 200tnots 1, page 10,

Dipentacrythritol Hexanitrate (DPEHN)

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| Campasition: % | Maleculer Weight: (C ₁₀ H ₁₆ N ₆ O ₁₉) 554 |
|---------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|
| C 21.7 H 2.9 N 15.2 ONO ₂ ONO ₂ | Oxygen Balance: CO., % -26 CO % + 3 |
| 0 00.2 CH2 CH2 | Density: gm/cc Crystal 1.63 |
| ON2OCH2C-CH2-CH2-CH2-CH2ONO2 | Molting Point: °C 73.7 |
| сн, | Freezing Point: *C |
| Impact Sensitivity, 2 Kg Wt: | Bailing Point: "C |
| Bureau of Mines Apparatus, cm 14 Somple Wt 20 mg Picatinny Arsenal Apparatus, in. 4 Sample Wt, mg 10 | Rofrective Index, nº nº nº |
| Friction Pendulum Test: | Vocuum Stability Testi |
| Steel Shoe Explodes | c⊥/40 Hrs, at 90°C |
| Fiber Shoe Unaffected | - 100°C 3.7 |
| Rifie Suilet Impact Test: Triais | 120°C 11+ |
| % Explosions | 135°C |
| Partials | 150°C |
| Burned | 200 Grem Banb Send Test: |
| Unaffected | Sand, gm 57.4 |
| Explosion Temperature: °C Seconds, 0.1 (no cap used) 1 300 5 Explodes 255 10 | Senskivity & Initiation: Minimum Detonating Charge, gm Mercury Fulminate Løad Azide Tatryi |
| 15 20 | Bellistic Morter, % TNY: (a) 142 |
| | Treuzi Tett, % YNT: (b) 128 |
| 75°C International Heat Test: % Loss in 48 Hrs | Fiate Dant Test: Method |
| 160°C Heat Test: | Condition |
| % Loss, 1st 48 Hrs 0.11 | Confined |
| % Loss, 2nd % Hrs 0.10 | Densily, gm/cc Brisonce, % TNT |
| Explosion in 100 Hrs None | |
| Flemmebility Index: | - Detension Rate: (c) Confinement Copper tube |
| Nygrescepickiy: % 0.03 | - Condition Pressed Charge Diameter, in. 0, 39 |
| | Density, gm/rc 1,59 |
| Valutility: | Rate, insters/second 7420 |

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Dipentaerythritol Hexanitrate (DPEHN)

| Freqmentation Tart: | Shaped Charge Effectiveness, TNT = 100: |
|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, lb | Glass Cones Steel Cones Hole Volume Hole Depth |
| Total No. of Fregments: For TNT | Color: White |
| For Subject HE 3 inch HE, MAZA1 Projectile, Let KC \: Density, gm/cc Charge Wt, Ib | Principal Uses: Ingredient of priming compositions |
| Total No. of Fregments: For TNT For Subject HE | Method of Looding: Pressed |
| For Subject ME | Leeding Density: gm/cc At 3000 to 4000 psi 1.59 |
| At 9 ft At 25¼ ft Density, gm/uc | Sterege: Method Dry |
| Bluet (Rolative to TNT): | Hazard Class (Quontity-Distance) Class 9 |
| Airi Peak Pressure Impulse Energy | Compatibility Group Exudation |
| Air, Confined: Impulse | Preparation: (Chemistry of Powder and Explosives, Davis) |
| Under Woter: Peck Pressure Impulse | 2(HO-CH ₂) ₄ C <u>Dehydration</u> (HO-CH ₂) ₃ C-O-C(CH ₂ -OH) ₃ (⁰ ₂ NO-CH ₂) ₃ C-O-C(CH ₂ -ONO ₂) ₃ |
| Energy Underground: Peak Pressure | Dipentaerythritol Hexanitrate is procured in the pure state (melting point 72°C) by fractional crystallization of crude PETN from moist acetone. |
| impulse Energy | Origin: Formed as an impurity in the prepa- ration of PEIN. Properties first described by W. Frederick and W. Brûn in 1930 (Berichts 63, 2861 (1930); Z. ges Schiess- Sprengstoffw 27, 73-6, 125-7, 156-8 (1932)). |
| | Heat of: Combustion, cal/gm 2260 |

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Dipentacrythritol Hexanitrate (DPEHN)

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References: 24

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

(b) A. Stettbacher, Die Schiess und Sprengstoffe, Leipsiz, p. 363.

(c) T. L. Davis, The Chemistry of Powder and Explosives, John Wiley and Sons, Inc., New York (1943) pp. 218-203.

(d) S. Livingston, <u>Characteristics of Explosives HMX and DPEHN</u>, PATR No. 1561, 6 September 1945.

Dynamite, Low Velocity, Picatinny Arsenal (LVD)

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| Composition: 99.5/0.5 RDX/1-MA dyc* 17.5 % | Molecular Weight: |
|------------------------------------------------------------------|-------------------------------------------|
| TVT 67.8 | Oxygen Balance: |
| Tripentserythritol 8.6 68/32 Vistsc No 1/DOS binders** 4.1 | CO, % CO % |
| Cellulose acetate, IH-1 2.0 | |
| *RDX, Class E; 1-MA is 96% pure 1-methylamino- anthraguinone. | Density: gm/cc Loading 0.9 |
| **Vistac No 1 is low MW polybutene; DOS is | Meiting Paint: "C |
| dioctylsebacste. C/H Raio | Freezing Point: "C |
| Impact Sensitivity, 2 Kg Wt: Bureou of Mines Apparatus, cm | Boiling Print: *C |
| Sample Wt 20 mg | Refrective Index, nº |
| Picatinny Arsenal Apparatus, in. 22 | n ⁹ |
| Sample Wt, mg * 19 | n ^o |
| Friction Pondulum Test: | |
| Steel Shoe Unaffected | Vocuum Stability Test: |
| Fiber Shoe Unaffected | cc/40 Hrs, at 90°C |
| | - 100°C |
| Rifie Sullet Impact Test: Trials | 120°C 0.90 |
| % | 135°C |
| Explosions | 150°C |
| Partials | |
| Burned | 200 Grem Bamb Sand Test: |
| Unoffected | Sond, gm 40.5 |
| Explosion Temperature: *C | Seneitivity to Initiatian: |
| Seconds, 0,1 (no cap used) | Minimum Detonating Charge, gm |
| 1 | Mercury Fulminate |
| 5 Ignites 480 | Leod Azide 0+20 |
| 10 | Tetryl 0-15 |
| 15 20 | Ballistic Morter, % TNT: 92 |
| | Troual Test, % TNT: |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dant Test: |
| | Method |
| 100°C Heat Test: | Condition |
| % Loss, 1st 48 Hirs | Confined |
| % Loss, 2nd 48 Hrs | Density, gm/cc |
| Explosion in 100 Hrs | Brisonce, % TNT |
| Stannanskillen tadam | - Detenstion Rote: |
| Flammability Index: | Confinement None |
| Hygroscopicity: % 0.31 | - Condition Hand tamped |
| 71°C, 95% RH. 30 days Satisfactory | Charge Diameter, in. 1,25 |
| Veletility: | Density, gm/cc 0.9 |
| · | Rate, meters/second 4377; or 14400 ft/sec |

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Dynamite, Low Velocity, Picatinny Arsenal (LVD)

AMCP 706-177

| Fragmentation Test: | Shaped Charge Effectiveness, TNT = 100: |
|---------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|
| rragmantation rest. | Shaped Charge Errechtenens, 11(1 2 100; |
| 90 mm HE, M73 Projectile, Lot WC-91; Density, gm/cc Charge Wt, lb | Glass Cones Steel Cone: Hole Volume Hole Depth |
| Total No. of Fragments: For TNT | Celer: Pink |
| For Subject HE 3 inch HE, M42A1 Prejectile, Lot KC-5: Density, gm/cc Charge Wt, Ib | Principal Usen: Excavation, demolition, and cratering |
| Totel Ne. of Fregments: For TNT For Subject HE | Method of Looding: Hall Packer machine loaded |
| Frogmant Valacity: ft/sec At 9 ft At 25½ ft | Leading Density: gm/cc 0.9 Tamped cartridge 1-1/2" diameter, 8" long Storage: |
| Density, gm/cc | Method Dry |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) Class 9 |
| Air: Peak Pressure Impulse Energy | Compatibility Group Group A |
| Air, Contined: Impulse | Sensitivity to Initiation:Stick dry, No. 6 Electric capStick dry, Corps of EngineersStick wet, Corps of EngineersPositive |
| Under Weise; Peak Pressure Impulse Energy | Air Gep Propagation: Max distance will, inch 2-1/2 min distance will not, inch 3 Stick Water Immersion: |
| Underground: Peak Pressure Impulse Energy | Weight gain, \$ 9-16 <u>Heat of:</u> Fxplosion, cal/gm 625 Gas Volume, cc/gm 611 <u>Cold Storage:</u> Plastic to -65°F Low Temperature Usage: |
| · · | -65°F, 1 day, M2 cap crimper Satisfactory |

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Dynamite, Low Velocity, Picatinny Arsenal (LVD)

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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:

Nobel 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 NG in the mixture. Later oridants and combustibles were substituted for the kieselguhr, and ammonium nitrate and/or nitrostarch replaced the NG, bringing into existence new types of dynamites. World War II military operations required special demolition and cratering explosives free from the objectionable characteristics of NG and many "dynamite substitutes" were developed for specific applications. The subject low velocity dynamite was developed in 1956 by Picetinny Arsenal (Ref a).

References: 25

(a) H. W. Voigt, <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 Picatinny Arsenal Technical Reports on Dynamites:

| <u>0</u> | <u>1</u> | 2 | <u>4</u> | 2 | <u>6</u> | ĩ | <u>8</u> | 2 |
|------------------------------|--------------|-------------|-------------|------|------------------------------|------------|-------------|------|
| 1260 1360 1720 1760 | 1381 1611 | 782 1532 | 864 1464 | 1285 | 1416 1436 1506 2056 | 507 957 | 848 1828 | 1819 |

²⁵See footnote 1, page 10.

Dynamite, Medium Velocity, Hercules (MVD)

AMCP 706-177

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| Composition: | Molecular Weight: | |
|---------------------------------------------------------------------|----------------------------------|----------------------------------------|
| % RDX 75 TNT 15 | Oxygen Balance: CO: % CO % | -51 |
| Starch 5 SAE No. 10 011 4 Vistanex oil gel* 1 | | ding 1.1 |
| *80/15/5, SAE No. 10 weight oil/Vistanex B- 120XC/Navy D2 wax. | Metting Point: "C | |
| C/H Ratio | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm' >100 | Nitroglycerin Equival | ent, % 60 |
| Sample Wt 20 mg 18 | Refractive Index, no | |
| Picatinny Arsenal Apparatus, in. 25 | ពង | |
| Sample Wt, mg | n 🕰 | |
| Friction Pendulum Test: | Vecuum Stability Test: | |
| Steel Shoe Craciles | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | <u>^</u> |
| Rifle Sullet Impact Test: Trials | - 100°C | 0.80 |
| % | 120°C | 0.94 |
| Explosions O | 135°C | |
| Partials O | 150°C | |
| Burned 10 | 200 Grem Bomb Send Test: | |
| Unaffected 90 | Sand, gm | 52.6 |
| Explosion Temperature: °C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Char | ge, gm |
| 1 5 | Mercury Fulminote | |
| 10 | Leod Azide | 0.20 |
| 15 | Tetryl | 0.10 |
| 20 | Ballistic Nuerter, % TNT: | 122 |
| 40 | Treuzi Test, % TNT: | |
| 75°C International Heat Test: | Plate Dent Test: | |
| % Loss in 48 Hrs | Method | |
| 100°C Heat Test: | Condition | |
| % Loss, 1st 48 Hrs 0.62 | Confined | |
| % Loss, 1st 46 Hrs 0.02 % Loss, 2nd 48 Hrs 0.12 | Density, gm/cc | |
| Explosion in 100 Hrs None | Brisonce, % TNT | |
| | - Detenation Rute: | · ــــــــــــــــــــــــــــــــــــ |
| Flummability Index: | Confinement | None |
| | - Condition | Machine tamped |
| Hygrescepicity: % | Charge Diameter, in. | 1.50 |
| 71°C, 95% RH, 30 days Satisfactory | Density, gm/cc | 1.1 |
| Voletility: | | -6600; or 20,000 ft/se |

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Dynamite, Medium Velocity, Hercules (MVD)

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| 90 mm HL, MY1 Projectile, Let WC-91: Density, gm/cc Glau Cones Steel Cones Total Ne. of Fregments: For TNT For Subject HE Buff 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Buff Tetal Ne. of Fregments: For TNT For Subject HE Principal Use: Excess tion, demolition, and cratering 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Method of Leading: Hall Packer matchine loaded For TNT For Subject HE Method of Leading: Hall Packer matchine loaded For TNT For Subject HE Leading Density: gm/cc 1.1 Tragment Velocity: ft/sec At 9 ft At 25½ ft Density: gm/cc 1.1 Baset Restaure Impulse Sensetivity to Initiation: Stick dry, No. 6 Electric cap Stick dry, No. 6 Electric cap Positive Stick dry, No. 6 Electric cap Positive Stick dry, No. 6 Electric cap Density: Corps of Engineers Positive Stick wet, Corps of Engineers Positive Stick wet, Corps of Engineers Positive Stick Vet, Corps of Positive Positive Stick Vet, Corps of Positive Positive Posi | Fragmentation Test: | Shayed Charge Effectiveness, TNT = 100: | | | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-----------------------------------------|-------------------|--|--|--|
| Chorge Wr, ib Hole Depth Tetel Ne. of Fregments: Euff For TNT For Subject HE 3 lack HE, M42A1 Projectile, Los KC-5: Density, gm/cc Chorge Wr, ib Principal Uses: Excervation, demolition, and cratering Total Ne. of Fregments: Mathed of Lossing: Hall Packer machine loaded For TNT For Subject HE Pregment Velocity: fr/sec A: At 25% ft Density, gm/cc Density, gm/cc Mathed of Lossing: Hall Packer machine loaded At 25% ft Density: gm/cc Density, gm/cc Storege: Air: Presture Impulse Exudation Energy Storege: Air: Peck Pressure Impulse Energy Useds: Veter: Peck Pressure Peck Pressure Energy Useds: Veter: Peck Pressure Peck Pressure Energy Useds: Veter: Peck Pressure Peck Pressure Energy Used segmend: Pector more store Peck Pressure Energy Used segreend: Pectof: <th>90 mm HE, M71 Projectile, Lot WC-91:</th> <th>Glass Cones Steel Con</th> <th>es</th> | 90 mm HE, M71 Projectile, Lot WC-91: | Glass Cones Steel Con | es | | | |
| Total No. of Frequents: For TNT For Subject HE Density, gm/cc J inch HE, M42A1 Projectile, Lar KC-3: Density, gm/cc Density, gm/cc Chara Excession, demolition, and cratering Tetel No. of Frequents: Mathed of Localing: Hall Packer machine loaded For TNT For Subject HE Prequent Velocity; fr/sec At 9 fr At 9 fr At 25% fr Density, gm/cc Leading Dessity; gm/cc 1.1 Cater: Mathed of Localing: Hall Packer machine loaded For TNT For Subject HE Leading Dessity; gm/cc 1.1 Prequent Velocity; fr/sec At 9 fr At 9 fr 1.1 At 9 fr At 25% fr Dessity; gm/cc 1.1 Density, gm/cc Mathod Dry Hazerd Class (Quontity-Distance) Class 9 Air: Peak Pressure Exudation Exudation Exudation Impulse Exit dry, Corp of Digineers Positive Pack Pressure Impulse Stack dry, Corp of Digineers Positive Vedergreend: Propagation: Mathed stance will, inch 1 1 Har Gep Propagation: Ma | Density, gm/cc | Hole Volume | | | | |
| For TNT For Subject HE 3 inch HE, M42A1 Projectile, Lee KC-3: Density, gm/cc Density, gm/cc Charge Wt, ib Tetel Ne. of Fregments: Mathed of Lose/lag: Hall Packer machine losded For TNT For Subject HE Present Valesity: fr/sec 1.1 Cartridge 1.1/2" dismeter, 8" long 1.1 Cartridge 1.1/2" dismeter, 8" long Density; gm/cc Ar 9 fr At 25½ ft Density, gm/cc Mathed Impulse Exact Class (Quontity-Distance) Impulse Exadotion Energy Sensitivity to Initiation: Stick dry, Dro 6 Electric cap Positive Stick dry, Orps of Digineers Positive Stick dry, Corps of Lagineers Usedegreened: Peak Pressure Stick dry, Corps of Signineers Positive Stick vet, Corps of Usedegreened: Peak Pressure Mathed ef Lose/lag: 4 tons rock/ton explositive Stick vet, Corps of Usedegreened: Peak Pressure Propagation: Weight gainer 25-27 Impulse Energy Stick dry, Mathed eg Stick to -70°F Usedegreened: Peak Pressure Stick dry, Mathed eg 25-27 Impulse Freege Stick dry, Mathed eg Stick to -70°F | Charge Wt, ib | Hole Depth | | | | |
| For TNT For Subject HE 3 inch HE, M42A1 Projectile, Los KC-3: Density, gm/cc Charge Wr, 1b Tetal Ne. of Fregments: For TNT For Subject HE Pregment Velocity: fr/sec At 25% ft Density, gm/cc Density, gm/cc Density, gm/cc Density, gm/cc At 25% ft Density, gm/cc Mathod Energy Air: Peck Pressure Impulse Under Weter: Peck Pressure Impulse Density of the tet TIME Peck Pressure Impulse Density of the tet TIME Density of the te | Total No. of Fragments: | Caler: | uff | | | |
| 3 inch HE, M42A1 Prejectile, Let KC-5: Density, gm/cc Charge Wr, 1b Tetal Na. of Fregments: For TNT For Subject HE Leading Density: gm/cc At 9 ft At 25% ft Density, gm/cc Biset (Relative to TNT): Air: Peak Pressure Impulse Energy Undergreend: | For TNT | | | | | |
| Jonaity, gam/cc Charge Wr, 1b Tetal Na. of Fregments: For TNT For Subject HE Leading Density: gm/cc 1.1 Gartridge 1.1/2" disameter, 6" long Ar 9 fr Ar 25% ft Density, gm/cc Bisst (Raletive to TNT): Air Peak Pressure Impulse Energy Undergreend: Impulse Impulse Energy Undergreend: Impulse Impulse Energy Undergreend: Impulse Energy < | For Subject HE | | ion, and | | | |
| Charge Wr, Ib Tetel Ne. of Fregments: For TNT For Subject HE Fregment Velocity: fr/sec At 9 fr. At 25½ fr Density, gm/cc Image: Relative to TNT): Blast (Relative to TNT): Air: Peak Pressure Impulse Energy Air, Cashined: Impulse Under Weter: Peak Pressure Impulse Under Weter: Peak Pressure Impulse Energy Under Weter: Peak Pressure Impulse Energy Under Weter: Peak Pressure Impulse Energy Under Gas Prosection: Mathed of Leeding: Hall Packer machine loaded Impulse Energy Under Gas Prosection: Peak Pressure Impulse Energy Under Gas Prosection: Peak Pressure Impulse Energy <th>3 inch HE, M42A1 Projectile, Lat KC-5:</th> <th>cratering</th> <th></th> | 3 inch HE, M42A1 Projectile, Lat KC-5: | cratering | | | | |
| Tetel Ne. of Frequents: Method of Localing: Hall Packer machine loaded For TNT For Subject HE Frequency Velocity: ft/sec 1.1 An 9 ft Air: Density: gm/cc Method Bisst (Relative to TNT): Method Air: Compatibility Group Impulse Exadding Earry Stack dry, No. 6 Electric cap Air: Stack dry, No. 6 Electric cap Impulse Stack dry, No. 6 Electric cap Impulse Stack dry, No. 6 Electric cap Impulse Stack dry, No. 6 Electric cap Vadar Weten: Pack Pressure Impulse Stack dry, No. 6 Electric cap Under Weten: Engineers Pack Pressure Air Gap Propagation: Man distance will not, inch 2-1/2 Quarry Performance: 4 tons rock/ton Undergressed: Stack water Immeration: Method Stack of: Energy Stack of: Deck Pressure Man distance will, not, inch 2-1/2 Quarry Performance: 4 tons rock/ton Energy Stack Water Immeration: Man distance will not, inch 2-1/2 | Density, gm/cc | | | | | |
| For TNT For Subject HE Fregment Velocity: ft/sec 1.1 At 9 ft At 251/3 ft Density, gm/cc Storege: Density, gm/cc Method Biset (Relative to TNT): Heared Cleas (Quantity-Distance) Air: Peak Pressure Impulse Exudation Energy Statk dry, No. 6 Electric cap Under Wressure Statk dry, No. 6 Electric cap Impulse Statk dry, No. 6 Electric cap Under Wressure Math distance will, inch Impulse Math distance will, inch Undergreend: Pook Pressure Impulse Math distance will, inch Undergreend: Poik Pressure Impulse Energy Undergreend: Poik Pressure Impulse Energy Undergreend: Poik Pressure Impulse Energy Energy Stick Water Immersion: Weight gain, 5 25-27 Heet of: Poil Storege: Energy Storege: Undergreemd: Poil Storege: Energy Storege:< | Charge Wt, Ib | | | | | |
| For TNT For Subject HE Image: Second Stress | Total No. of Fregments: | Method of Longine: Hall Packer much | ine losdei | | | |
| Leading Density: gm/cc 1-1 Fregment Velecity: ft/sec A: 9 ft At 9 ft A: 25½ ft Density. gm/cc Storage: Density. gm/cc Method Density. gm/cc Method Blast (Relative to TNT): Hazord Class (Quantity-Distance) Class 9 Compatibility Group Group A Exudation Peak Pressure Exudation Impulse Exit dry, No. 6 Electric cap Pook Pressure Stick dry, No. 6 Electric cap Impulse Stick dry, Corps of Engineers Pook Pressure Air Gap Propagation: Max distance will, inch 1 Min distance will, inch 2-1/2 Min distance will, inch 1 Min distance will, inch 1 Min distance will, inch 2-1/2 Under Wressure Min distance will, inch 1 Impulse Energy Undergreund: Yestick Water Immeration: Weight gain, 5 Pook Pressure Stick Water Immeration: Weight gain, 5 Impulse Energy Energy Stick Water Immeration: Weight gain, 5 Cold Storage: Plastic to -70°F Low Temperature Usage: -50°F, 1 day, M2 cap <th>For TNT</th> <th></th> <th></th> | For TNT | | | | | |
| Frequency Velocity: ft/sec A: 21/2" diameter, 8" long A: 25% ft Storage: Density, gm/cc Method Dry Size: (Reletive to TNT): Hearond Cless (Quantity-Distance) Class 9 Air: Peak Pressure Compatibility Group Group A Impulse Exudation Exudation Air, Confined: Stick dry, No. 6 Electric cap Positive Impulse Stick dry, No. 6 Electric cap Positive Vector: Peak Pressure Engineers Positive Impulse Stick dry, No. 6 Electric cap Positive Vector: Stick dry, Corps of Engineers Positive Vector: Peak Pressure Inpulse Engineers > 50% Positive Vaderground: Peak Pressure Min distance will, inch 1 Min distance will, not, inch 2-1/2 Quarry Performance: 4 tors more region: Vector Impulse Energy Stick Water Immeraion: Weight gain, % 25-27 Impulse Energy Energion: 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Tempersture Us | For Subject HE | Landian Density on /cc | . 1 | | | |
| Tregment vetery: It/sec At 9 ft At 25½ ft Density, gm/cc Blast (Reletive to TNT): Mathod Blast (Reletive to TNT): Hazord Cless (Quantity-Distance) Camposibility Group Group A Peak Pressure Exudation Impulse Exudation Mathod Exudation Air: Compatibility Group Group A Peak Pressure Exudation Exudation Impulse Exudation Exudation Under Weter: Pack Pressure Peak Pressure Impulse Energy Sensitivity to Initiation: Stick dry, No. 6 Electric cap Positive Under Weter: Pack Pressure Engineers > 50% Positive Impulse Energy Min distance will, inch 1 Min distance will, not, inch 2-1/2 Quarry Performance: 4 tons rock/ton Vadergreund: Water Immeraion: Weight gain, % 25-27 Impulse Energy 935 Gas Volume, cc/gm 945 Cold Storege: Plastic to -70°F Low Temperature Usage: -00°F7, 1 day, M2 cap | | | | | | |
| At 25½ ft Sterregs: Density, gm/cc Mathod Dry Blace (Relative to TNT): Harod Class (Quontity-Distance) Class 9 Air: Peak Pressure Group A Impulse Energy Exudation Air: Compatibility Group Group A Peak Pressure Energy Exudation Air: Sensitivity to Initiation: Stick dry, No. 5 Electric cap Impulse Stick dry, No. 5 Electric cap Positive Stick vet, Corps of Engineers Positive Stick dry, Corps of Engineers Under Water: Peak Pressure Air Gap Propagation: Min distance will, inch 1 Impulse Min distance will not, inch 2-1/2 Quarry Performance: 4 tons rock/ton Undergreund: Stick Water Immersion: explosive Peak Pressure Stick Water Immersion: 935 Impulse Energy Stick Vater Immersion: 945 Cold Storege: Plastic to -70°F Low Tempersture Usage: -65°F, 1 day, M2 cap | | | | | | |
| Method Dry Bisst (Relative to TNT): Hazard Class (Quantity-Distance) Class 9 Air: Peak Pressure Group A Impulse Exudation Exudation Air, Coeffined: Sensitivity to Initiation: Sensitive to an initiation: Air, Coeffined: Sensitivity to Initiation: Sensitive to an initiation: Air, Coeffined: Sensitivity to Initiation: Sensitive to an initiation: Impulse Stick dry, No. 6 Electric cap Positive Stick dry, Corps of Engineers Positive Vader Water: Engineers > 50% Positive Peak Pressure Air Gap Propagation: Min distance will, inch 1 Impulse Min distance will not, inch 2-1/2 Quarry Performance: 4 tons rock/ton Underground: Stick Water Intersion: weight gain, % 25-27 Impulse Heat of: Explosion, calgm 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Temperature Usage: | | Storage: | | | | |
| Air: Peak Pressure Impulse Energy Air, Casfined: Impulse Under Weter: Peak Pressure Impulse Under Weter: Peak Pressure Impulse Energy Under Weter: Peak Pressure Impulse Energy Under Pressure Impulse Energy Stick Vater Immersion: Weight gain, % Composibility Group Engineers Positive Air Gap Propagation: Man distance will, inch 1 Man distance will, inch 2-1/2 Quarry Performance: 4 tons rock/ton Weight gain, % Cold Storege: Plastic to -70°F Low Temperature Usege: -65°F, 1 day, M2 cap | Density, gm/cc | Method I |)ary | | | |
| Peak Pressure Exudation Impulse Exudation Air, Confined: Sensitivity to Initiation: Impulse Stick dry, No. 6 Electric cap Positive Stick dry, Corps of Engineers Positive Stick dry, Corps of Engineers Positive Under Water: Engineers > 50% Positive Peak Pressure Air Cap Propagation: Impulse Max distance will, inch 1 Impulse Min distance will not, inch 2-1/2 Quarry Performance: 4 tons rock/ton Vaderground: Stick Water Immersion: Peak Pressure Heat of: Impulse Energy Underground: 25-27 Impulse Explosion, cal/gm 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Temperature Usage: -65°F, 1 day, M2 cap | Biast (Relative to TNT): | Hazard Class (Quantity-Distance) (| 1448 9 | | | |
| Energy Air, Ceefined: Impulse Impulse Peck Pressure Impulse Energy Underground: Peck Pressure Impulse Energy | | Compatibility Group (| roup A | | | |
| Energy Air, Cenfined: Impulse Under Weter: Peck Pressure Impulse Underground: Peck Pressure Impulse Energy Underground: Peck Pressure Impulse Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Energy Ene | Impulse | Exudation | | | | |
| Air, Canfined: Impulse Sensitivity to Initiation: Stick dry, No. 6 Electric cap Positive Stick dry, Corps of Engineers Positive Stick vet, Corps of Engineers > 50% Positive Under Weter: Peak Pressure Impulse Air Gap Propagation: Max distance will, inch 1 Min distance will, nch 2-1/2 Underground: Peak Pressure Impulse Max distance will, inch 1 Min distance will not, inch 2-1/2 Underground: Peak Pressure Impulse Stick Water Immeraion: Weight gain, % Energy Stick Water Immeraion: Weight gain, % Underground: Peak Pressure Impulse 935 Gas Volume, cc/gm Underground: Peak Pressure 935 Gas Volume, cc/gm | • | | | | | |
| ImpulseStick dry, Corps of EngineersPositiveUnder Weter: Peck PressureEngineers> 50% PositiveImpulseAir Gap Propagation: Max distance will, inch 1 Min distance will not, inch 2-1/2Underground: Peck PressureQuarry Performance: Weight gain, %25-27Impulse EnergyStick Water Immeraion: Weight gain, %935 Gas Volume, cc/gm945 Cold Storage: Plastic to -70°FLow Temperature Usage: -65°F, 1 day, M2 capCorps of EngineersPositive | •• | Sensitivity to Initiation: | | | | |
| Under Weter: Stick wet, Corps of Peak Pressure Engineers > 50% Positive Impulse Max distance will, inch 1 Energy Max distance will, inch 1 Underground: Quarry Performance: 4 tons rock/ton Underground: explosive Peak Pressure Stick Water Immersion: Impulse Weight gain, % Impulse Explosion, cal/gm Impulse Explosion, cal/gm Impulse Old Storage: Icov Temperature Usage: -65°F, 1 day, M2 cap | | | | | | |
| Under Weter: Engineers > 50% Positive Peck Pressure Air Gap Propagation: impulse Max distance will, inch 1 Energy Quarry Performance: 4 tons rock/ton Underground: explosive Peck Pressure Stick Water Immeration: Impulse Weight gain, % 25-27 Impulse Explosion, cal/gm 935 Gas Volume, cc/gm 945 Cold Storage: Low Temperature Usage: -65°F, 1 day, M2 cap | impulse | | Positive | | | |
| Peak Pressure Air Gap Propagation: Max distance will, inch 1 Min distance will not, inch 2-1/2 Energy Quarry Performance: 4 tons rock/ton explosive Undergreund: Peak Pressure Impulse Stick Water Immersion: Weight gain, % 25-27 Impulse Heat of: Explosion, cal/gm 935 Gas Volume, cc/gm 945 Cold Storage: -65°F, 1 day, M2 cap Plastic to -70°F | Under Weter: | | 50% Positive | | | |
| Energy Min distance will not, inch 2-1/2 Energy Quarry Performance: 4 tons rock/ton Underground: explosive Peck Pressure Stick Water Immeraion: Impulse Weight gain, % Energy 935 Gas Volume, cc/gm 945 Cold Storege: Plastic to -70°F Low Temperature Usage: -65°F, 1 day, M2 cap | | | | | | |
| Energy Underground: Peak Pressure impulse Energy Quarry Performance: 4 tons rock/ton explosive Stick Water Immeraion: Weight gain, % 25-27 Heat of: Explosion, cal/gm 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Temperature Usage: -65°F, 1 day, M2 cap | Impulse | | | | | |
| Undergreenes: Peck Pressure Peck Pressure Stick Water Immeraion: Impulse Weight gain, % Energy Heat of: Explosion, cal/gm 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Temperature Usage: -65°F, 1 day, M2 cap | Energy | | | | | |
| Impulse Weight gain, % 25-27 Energy Heat of: 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Temperature Usage: -65°F, 1 day, M2 cap | Underground: | | explosivo | | | |
| Impulse Heat of: 935 Explosion, cal/gm 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Temperature Ussge: -65°F, 1 day, M2 cap | Peak Pressure | |)F 07 | | | |
| Erelosion, cal/gm 935 Gas Volume, cc/gm 945 Cold Storage: Plastic to -70°F Low Temperature Ussge: -65°F, 1 day, M2 cap | Impulse | | -J-E1 | | | |
| Low Temperature Ussge: -65°F, 1 day, M2 cap | Energy | Explosion, cal/gm | | | | |
| -65°F, 1 day, M2 cap | | Cold Storage: Plastic to - | 70 ⁰ F | | | |
| | | -65°F, 1 day, M2 cap | fectory | | | |

Dynamite, Medium Velocity, Hercules (MVD)

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Prepayation:

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Monufactured 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 excavation, demolition, and cratering operations for which standard high explosives are unsuitably. 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 2086, 15 August 1952, Army Contract DA-36-034-ORD-110.

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

26See footnote 1, rage 10.

| Composition: % | Molecular Weight: Approximately 503 |
|-------------------------------------------------------|-------------------------------------|
| Nitrocellulose, 13.25% N 80 | Oxygen Balence: |
| Barium Nitrate 8 | CO, % +5 |
| Potassium Nitrate 8 Starch 3 | CO % -25 |
| Diphenylamine 0.75 | Density: gm/cc |
| Aurine 0.25 | Maiting Point: *C |
| C/H Ratio | Freezing Point: "C |
| Impact Sansitivity, 2 Kg Wt: | Beiling Pelat: *C |
| Bureau of Mines Apparatus, cm 19 Sample Wt 20 mg | Refractive Index, nº |
| Picatinay Arsenal Apparatus, in. | no. |
| Sample Wt, mg 20 | n <u>D</u> |
| | |
| Friction Pendulum Test: Steel Shoe Snaps | Vocuum Stability Test: |
| Steel Shoe Sline Sline Sline Sline Sline Shoe | cc/40 Hrs, at 90°C |
| | 100°C |
| Rifle Bullet Impact Yest: Trials | 120°C |
| 96 | 135°C |
| Explosions | 150°C |
| Partials | |
| Burned | 200 Gram Bond Sand Test: |
| Unaffected | Sand, gm 46.8 |
| Explosion Temperature: C | Sansitivity to Initiation: |
| Seconds, 0.1 (no cap used) | Minimum Dutonating Charge, gm |
| 1 5 Decomposes 200 | Mercury Fulminate 0.22 |
| | Lead Azide |
| 15 | Tetryl : |
| 20 | Bailistic Mortor, % TNT: |
| | Troux Test, % TNT: |
| 75°C International Heat Test: % Loss in 48 Hrs 1.8 | Plate Deat Test: |
| % Loss in 48 Hrs 1.8 | Method |
| 100°C Heat Test: | Condition |
| °i Loss, 1st 48 Hrs 2.0 | Confined |
| % Loss, 2nd 48 Hrs 0.2 | Density, gm/cc |
| Explosion in 100 Hrs None | Brisance, % TNT |
| | Detanetion Kate: |
| Flammability Index: | Confinement |
| Hygroscopicity: % 30°C, 30% RH 6.2 | Condition Cliarge Diameter, in. |
| | Density, gm/cc |
| Voletility: | Rate, meters/second |

EC Blank Fire

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AMCP 706-177 EC Blank Fire Frequentation Test: Sheped Charge Effectiveness, TNT = 100: 90 mm ME, M71 Projectile, Let WC-91: Glass Cones Steel Cones Hole Volunia Density, gm/cc Hole Depth Charge Wt, Ib Total No. of Fragmants: Celor: For TNT For Subject HE Principul Uses: Grenades; caliber .30 blank 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib Yotel No. of Fragments: Method of Localing: Loose For YNT For Subject HE Leeding Density: gm/cc 0.40 Fregment Velocity: ft/sec At 9 ft At 251/2 ft Storuge: Elensity, gm/cc Method Wet Blact (Relative to TNT); Hazard Class (Quantity-Distance) Class O **Compatibility Group** Group J Ain Peak Pressure Exudation Impulse Energy Preparation: EC Blank Fire is a partially colloided propellant canufactured by a pro-Air, Confined: Impulse cess using either acetons and ethanol or a mixture of butyl acetate and benzene to gelatinize only a part of the nitrocellu-**Under Water:** lose. The process is controlled so that Peak Pressure the product passes through a No. 12 sieve Impulse and is retained on a No. 50 sieve. Energy Origin: Undergrownd: Invented in 1882 as bulk sporting (amokethe Explosive Company (whence the name "EC") in England (British Patent 619). Peak Pressure Impulse Energy References:²⁷(a) See the following Picatinny Arsenal Technical Reports on EC Blank Fire: 891, 200 232 1373 854 65 667, 120°C Heat Test: Minutes Salmon Pink 150 901, 372, 512, 822, 233, 1373, 854, 65, 667, 817, 69, 579 and 1399. Red Fumes 300+ Amplodes 300+

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²⁷See foutnote 1, page 10.

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Eduatol, 55/45

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| Composition: | Molecular Weight: | 178 |
|-----------------------------------------------------|----------------------------------------------------|------------------------------------------|
| π Haleite (Ethylene Dinitzamine) 55 | Oxygon Bolence: | |
| TNT 45 | CO, % | -51 -17 |
| TNT 45 | Density: gm/cc Cast | 1.62 |
| | Metting Point: *C Eutectic | 80 |
| C/H Ratio | Freezing Point: *C | |
| Impact Sansitivity, 2 Kg Wt: | Builing Point: "C | |
| Bureau of Mines Apparatus, cm 95 Sample Wt 20 mg | Refrective Index, no | |
| Picatinny Arsenal Apparatus, in. | All A | |
| Sample Wt, mg 20 | n ₂₀ | |
| | | |
| Friction Pendulum Test: Steel Shoa Unaffected | Vacuum Stability Test: | |
| Steel Shoe Unaffected Fiber Shoe Unaffected | cc/40 Hrs, at 90°C | |
| | - 100°C | 1.0 |
| Rifle Bullet Impact Text: Trials | 120°C | 11+ |
| Explosions 0 | 135°C | |
| Explosions O Partials O | 150°C | |
| Burned 7 | | |
| Unaffected 93 | 200 Gram Bound Sand Test: Sand, am | 49.4 |
| | | |
| Explosion Yempereture: * 'C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) 435 1 248 | Minimum Detonating Charge, gr Mercury Fulminate | 0.024 |
| 5 Decomposes 190 | Laod Azide | 0.26* |
| 10 183 | | |
| 15 176 | *Alternative initiating char | 248. |
| 20 3.68 | Sallistic Mortar, % TNT: (a) | 119 |
| *Composition Haleite/TNT, 60/40. | Troust Toxi, % TNT: (b) | 120 |
| 75°C International Heat Tast: | Plate Dent Test: | 52/48 |
| % Loss in 48 Hrs | Method | В |
| 100'C Heet Test: | Condition | Cast |
| % Loss, 1st 48 Hrs 0.2 | Confined | No |
| % Loss, 2nd 48 Hrs 0.1 | Density, gm/cc | 1.62 |
| Explosion in 100 His None | Brisance, % TNT | 112 |
| | Detenation Rate: | an a |
| Flammability Index: Will not continue to burn | Confinement | None |
| | - Condition | Cast |
| Hygrescepicity: % None | Charge Diameter, in, | 1.0 |
| | Density, gm/cc | 1.63 |
| Velatility: | Rate, meters/second | 7340 |

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Ednatol, 55/45

AMCP 706-177

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|----------------------------------------|-------------|--------------|----------------------------------------------------------------|-------------------|
| Fragment You Test: | | | Sheped Churge Effectiveness, TNT = | 100: 50/50 |
| 90 mm HE, M71 Projectile, | Let WC-91: | | Glass Cones Stee | i Cones |
| Density, grn/cc | 1.56 | 1.62 | Hole Volume 126 1 | .23 |
| Charge Wt, ib | 2.065 | 2.092 | Hole Depth 117 1 | 21 |
| Total No. of Fragmantu: | | | Coler: | Yellow |
| For TNT | 703 | 703 | | |
| For Subject HE | 842 | 902 | Principal Uson: Projectiles, t | |
| 3 inch HE, M42A1 Projectil | , Los XC-3: | | emmunition con | ponenta |
| Density, gm/cc | | 1.60 | | |
| Charge Wt, Ib | | 0.845 | | |
| Total No. of Fragments: | | | Motion of Londing: | Cast |
| For TNT | | 514 | | |
| For Subject HE | | 536 | Londing Doneity: gm/cc | 1.65 |
| Frequent Valacity: f0/sec | | | | 2.09 |
| At 9 ft | | 2730 | | ····· |
| At 251/2 fr | | 2430 | Stereger | |
| Density, gm/cc | | 1.62 | Method | Dry |
| | | | memo: | шу |
| Bizst (Relative to TMT): | | (d, e) | Hazard Class (Quantity-Distance) | Class 9 |
| Airs | | | Compatibility Group | Group I |
| Peak Pressure | | 108 | 1 | |
| Impulze | | 110 | Exudation Does t | out exude at 65°C |
| Energy | | 108 | | |
| Air, Contined: | | | Eutectic Temperature, °C: | 79.8 |
| Impulse | | | gm Haleite/100 gm TNT 79.8°C | 0.48 |
| | | | 95.0°C | 1.12 |
| Under Walars | | | Compatibility with Metals: | |
| Peak Pressure Impulse | | u = ' | Dry: Brass, aluminum, stat | nless staal |
| | | 113 | mild steel, mild steel costed | |
| Energy | | 113 | proof black paint, and mild a | |
| Underground: | | | with cadmium or nickel are up per, magnetium, magnesium-alu | |
| Peak Pressure | | | mild steel plated with copper | |
| Impulse | | | slightly affected. | |
| Energy | | | Wet: Copper, brass, magnes | |
| Booster Sensitivity Te | sti | (d) | eluminum elloy, mild steel, a | |
| Condition | | Cast | with acid-proof black paint a plated with copper, cadmium, | |
| Tetryl, gm War in son 500 Dat | | 100 1.28 | are heavily attacked. Alumin | |
| Wax, in. for 50% Det Density, gm/ce | 014 01 01 | 1.20 | affected and stainless steel | |
| | | | | |

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Ednatol, 55/45

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Preparation:

Wet Haleite is added slowly to molton INT heated at about 100° C in a steam jacketed melting kettle coulpped 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 Hsleite (EINA) and TNT, designsted Ednatol, were developed at Picatinny Arsenal just prior to World War II.

References: 28

(a) L. C. S ith and E. G. 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 C. 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 Tenting, OSRD Report No. 803, 11 August 1942.

(d) L. C. Smith and S. R. Welton, <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., Blast Effects of Bomb Explosives, PA Tech Div Lecture, 9 April 1948.

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

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

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

| <u>o</u> | 1 | 2 | 3 | <u>4</u> | 2 | <u>6</u> | I | <u>8</u> | 2 |
|------------------------------|----------------------|----------------------|----------------------|--------------|----------------------|----------|------------------------------|----------------------|-----------------------|
| 1290 1400 1420 1530 | 1291 1451 1651 | 1162 1372 1482 | 1193 1363 1493 | 1294 1434 | 1325 1395 1885 | 1796 | 1457 1477 1737 1797 | 1198 1388 1838 | 1 <i>2</i> 79 1469 |

28See footnote 1, page 10.

Ethylane Glycol Di-Trinitrobutyrate (GTNB)

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AMCP 706-177

| Composition: % | Molecules Weight: (C10H12N6016) | 468 |
|--------------------------------------------------------------------------------------------|----------------------------------------------|-----------|
| с 25.6 н 2.6 | Oxygen Belence: CO ₂ % CO % | - 34 0 |
| N 17.1 | Density: gm/cc Crystal | 1.63 |
| о 54.7 сн ₂ со ₂ сн ₂ сн ₂ с(NO ₃) | Molting Point: "C | 96 |
| C/H Rotio 0.235 | Freezing Point: *C | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Boiling Point: *C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. | Refrective Index, np | |
| Sample Wt, mg | nS | |
| · · · · · · · · · · · · · · · · · · · | | |
| Friction Pendulum Test; | Vocuum Stability Tuot: | |
| Steel Shoe | cc/40 Hrs, at | |
| Fiber Shoe | 90°C | |
| Rifle Builet Impact Test: Trials | 120°C | |
| % | 135*C | |
| Explosions | 150*C | |
| Partials | | |
| Burried Unoffected | 206 Grem Bemb Send Test: Sond, am | |
| | | |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cop used) | Minimum Detonating Charge, gm | |
| 5 50% point 230 | Mercury Fulminate Leod Azide | |
| 10 | Tetryl | |
| 15 | ······································ | |
| 20 | Bellistic Marter, % TNT: | |
| 75°C International Hout Test: | Treuxi Test, % TNT: | |
| % Loss in 48 Hrs | Plate Dent Test: Mathod | |
| 100°C Heat Test: | Condition | |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | |
| Explosion in 100 Hrs | Brisonce, % TNT | |
| Flammability Index: | Detensition Rote: Confinement | |
| | Condition | |
| Hygroscopicity: % | Charge Diameter, In. | |
| | Density, gm/cc | 1.63 |
| Velatility: | | 2103 |

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Ethylene Glycol Di-Trinitrobutyrate (GTNB)

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| Fragmantation Test: | Shaped Chargo Effectiveness, Ti | NT == 100: | |
|----------------------------------------|----------------------------------------------|----------------------------------|--|
| 90 mm HE, M71 Projectile, Let WC-91: | Glass Convis | Steel Cones | |
| Density, gm/cc | Hole Volume | | |
| Charge Wt, Ib | Hole Depth | | |
| Charge With 10 | | | |
| Total No. of Fragments: | Celer: | | |
| For TNT | Color: | | |
| For Subject HE | | | |
| | Principal Uses: Casting me | dium for HE compound | |
| 3 Inch HE, M42A1 Projectile, Lot KC-5: | | | |
| Density, gm/cc | | | |
| Charge Wt, Ib | | | |
| Total No. of Fragments; | | | |
| For TNT | Method of Loading: | Cast | |
| For Subject HE | | | |
| | Looding Density: gm/cc | 1.60 | |
| Fragmont Velocity: It/sec | | | |
| At 9 ft | | | |
| At 2514 ft | Storage: | | |
| Density, gm/cc | Method | Dry | |
| | metrica | LEy | |
| Blast (Kalative to TNY): | Hazard Class (Quantity-Dista | Hazard Class (Quantity-Distance) | |
| Airs | Compatibility Group | | |
| Peak Pressure | | | |
| Impulse | Exudation | None | |
| Energy | | | |
| | · Preparation: | (a) | |
| Ale, Configuration | | ••• | |
| Impulse | By the addition of niglycol discrylate. As t | | |
| Under Weturi | ration often leads to pr | oducts difficult to | |
| Poak Pressure | purify, a preparation fr | om ethylene glycol | |
| Impulse | and pure trinitrobutyric | acid is in process. | |
| Energy | Origins | | |
| Undergrounds | First synthesized in : | 1951 by the U.S. | |
| Peak Pressure | Rubber Company, Research | and Development | |
| Impulse | General Laboratories, Pa | ssaic, New Jersey. | |
| Energy | Viscosity, poises: | | |
| | Temp, 98.9°C 106.5°C | 0.246 | |
| | | 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

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(a) U. S. Mubber 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 NOL Letter from Dr. D. V. Sichman to Commanding Officer, Picatinny Arsenal, 29 November 1955 (ORDEB 471.86/159-1; Serial No. 02894).

²⁹See footnote 1, page 10.

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Explosive D (Ammonium Picrete)

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| Cast position: % | Malacular Weight: (C6H6N407) | 246 |
|---------------------------------------------------------|-------------------------------|--------------|
| с 29.3 о-ян | Oxygon Belance: | |
| H 2.4 02NNO2 | CO, % | -52 -13 |
| | | |
| N 22.7 | Density: gm/cc Crystal | 1.72 |
| o 45.6 | Melting Peint: *C Decomposes | 265 |
| C/H Ratio 0.317 NO ₂ | Freezing Point: *C | |
| Impace Sansitivity, 2 Kg We: | Beiling Point: *C | |
| Buniau of Minus Apparatus, cm Sample Wt 20 mg | Refrective Index, non ag | 1.508 |
| Picatinny Arsenai Apparatus, in. 17 Sample Wt. ma 18 | | |
| Sample Wr, mg 18 | bo | 1.870 |
| | | 1.907 |
| Friction Foundations Test: | Vocuum Stability Test: | |
| Steel Shoe Unaffected | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | 0.2 |
| Rifle Bullet Impact Tuet: Trials | | • |
| % | 120*C | 0.4 |
| Explosions 0 | 135°C | |
| Portick 0 | 150°C | 0.4 |
| Burned 30 | 200 Grom Bomb Sand Yest: | |
| Unoffected 70 | Sand, gm | 39+5 |
| Explainer Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cop used) 405 | Minimum Detonating Charge, gm | |
| 1 367 | Mercury Fulminate | |
| 5 Decomposes 318 | Lead Azide | 0.20 |
| 10 314 | Tetryi | 0.06 |
| 15 2 99 | Ballistic Mortur, % TNT: (a) | 99 |
| 20 295 | Yruuzi Teat, % TNT: | 77 |
| 75°C International Host Yest: | Plate Dent Test: | |
| % Loss in 48 Hrs | Method | A |
| | Condition | Proseed |
| 100°C Hant Test: | C and | Yes |
| % Loss, 1st 48 Hrs 0.1 | Density, gm/cc | 1.50 |
| % Loss, 2nd 48 Hrs 0.1 | Brisance, % TNT | 91 |
| Explosion in 100 Hrs None | | /* |
| Hannability Index: | Confinement | None |
| | Condition | Pressed |
| Hygroservicky: % 100% RH 0.1 | | |
| | Charge Diameter, in. | 1.0 |
| Veletility | Density, gm/cc | 1,95 6850 |
| • | Rate, meters/second | 0070 |

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Explosive D (Ammonium Picrate)

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| Fregmentation Test: | | Shaped Charge Effectiveness, TNT = 100: | | | |
|----------------------------------|--------|-----------------------------------------|----------------------------|--|--|
| 90 mm HE, M71 Projectile, Lat | WC-91: | Glass Cones | Steel Cones | | |
| Density, gm/cc | 1.50 | Hole Volume | | | |
| Charge Wt, Ib | 1.94 | Hole Depth | | | |
| Total No. of Frequents: | | | | | |
| For TNT | 703 | Celer: | Yellow-orange | | |
| For Subject HE | 649 | Principal Uses: AP proje | ectiles and bombs | | |
| 3 inch HE, M42A1 Projectile, Let | KC-5: | | | | |
| Density, gm/cc | 1.55 | | | | |
| Charge Wt, ib | 0.82 | | | | |
| Total No. of Fragmonts: | | Method of Loading: | Pressed | | |
| For TNT | 514 | | LIMBOCH | | |
| For Subject HE | 508 | | | | |
| | | | $x 10^3$ | | |
| Frequent Velacity: it/sec | | · 3 5 10 1.33 1.41 1.47 | 12 15 20 1.49 1.51 1.53 | | |
| At 9 ft At 25½ ft | | Storege: | | | |
| Density, gm/cc | | | | | |
| | | Method | Dry | | |
| Blast (Roistive to TNT): | ······ | Hozard Class (Quantity-Dis | itance) Class 9 | | |
| Airt | | Compatibility Group | Group I | | |
| Peak Pressure | | | | | |
| Impulse | | Exudation | None at 65°C | | |
| Energy | | | | | |
| Air, Confinad: | | Sensitivity to Electron | static | | |
| Impulse | | Discharge, Joules: | (d) | | |
| | • | Through 100 Mesh: | | | |
| Under Water: Peak Pressure | | Confined | 6.0 | | |
| Impulse | | Unconfined | 0.025 | | |
| Energy | | Booster Sensitivity Ter | | | |
| | | Condition Tetryl, gm | Pressed 100 | | |
| Underground: | | Wax, in. Sov 50% D | | | |
| Peck Pressure | | Density, gm/cc | 1.54 | | |
| Impulse | | Heat of: | | | |
| Energy | | Combustion, cal/gm | | | |
| | | Explosion, cal/gm | 800 | | |
| | | Formation, cal/gm | 395 | | |
| | | | | | |
| | | | | | |
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Explosive D (Ammonium Picrate)

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Preparation:

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

Effect of Storage on Sand Test Values:

| | | | imum Mating Marge | |
|------------------------|------------------------|------------------------------|-------------------------|-------------------------|
| Stor Years | se C | Mercury Fulminate (gm) | Tetryl (gm) | Sand Crushed (gm) |
| 0 3.5 2 # 4 # | 50 Normal Normal | 0.25 | 0.06 0.03 0.04 | 23 23 23 23 |
| 2 ** | 50 | 0.24 | | 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)

**

| Wa | ter | ! | Alcohol | | 1 Acetate |
|-----------|-----------|---------------------|----------------------------------|---------------|----------------------------------|
| °C | £ | °c | ٤ | °c | ź |
| 20 100 | 1.1 75 | 0 10 30 50 | 0.515 0.690 1.050 1.890 | 0 10 30 | 0.290 0.300 0.380 0.450 |
| | | 20 80 | 3,620 | 50 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 (associum 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 perts of water.

References: 30

(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>, OSRD Report No. 5746, 27 December 1945.

305ee footnote 1, page 10.

Explosive D (Ammonium Picrate)

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

(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) 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, Eureau of Mines, RI 3852, 1946.

(c) Various sources in the open literature.

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

| <u>o</u> | <u>1</u> | 2 | 3 | 4 | 5 | <u>6</u> | ĩ | <u>8</u> | 2 |
|--------------------|--------------|--------------------------------------------|-----|-----------------------------------|---------------------------------------------------|------------------------------------------|--------------|--------------------|--------------|
| 340 870 1380 | 1441 1651 | 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 | 328 838 1838 | 1729 1759 |

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Glycerol Monolactate Trinitrate (GLTN) Liquid

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| Composition: | Molecular Weight: (C6H9N3011) | 299 |
|------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| с 24.1 0 оно ₂ н 3.0 сн ₂ -0-с-си-сн ₃ | Oxygen Belance: CO ₂ % CO % | 30 3 |
| N 14.1 CH-ONO2 | Density: gm/cc Liquià | 1.47 |
| 0 58.8 CH2-0NO2 | Melting Point: *C | |
| C/H Ratio 0.180 | Freezing Peint: *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 15 (1 1b wt); 42 | Boiling Point: "C | |
| Sample Wt 20 mg Picotinny Arsenal Apparatus, in. Sample Wt, mg | Refrective Index, n ^D _M , n ^D _M , n ^D _M , n ^D _M , | 1.8 2 |
| Friction Pendulum Test: Steel Shoe Unaffected Fiber Shoe Unaffected | Vecuum Stability Test: cc/40 Hrs, at 90°C 100°C | |
| Rifle Bullet Import Test: Trials % Explosions Partials | 120°C 135°C 150°C | 5.9 |
| Burned Unaffected | 200 Grem Bomb Send Text: Sand, gm | , 13,1 |
| Explorion Temperature: *C Seconds, 0.1 (no cap used) 1 5 223 10 15 20 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryl Belliutic Merter, % TNT: | |
| | - Trouxi Test, % TNT: | |
| 73°C International Heat Test* % Lots in 48 Hrs | Plate Deat Test: Method | |
| 100°C Heet Test: % Loss, 1st 48 Hrs 2.5 % Loss, 2nd 48 Hrs 1.8 Explosion in 100 Hrs Note | Condition Confined Density, gm/cc Brisance, % TNT | |
| Flemmebility Index: | - Detenation Rate: Confinement | |
| Hygroscopicity: % | - Condition Charge Diameter, in. | |
| Veletility: 60°C, mg/cm ² /hr 28 | Density, gm/cc Rate, meters/second | |

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Glycerol Monolactate Trinitrate (GLTN) Liquid

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| Fragmontation Test: | Shaped Charge Effoctiveness, TNT = 100: | | | |
|----------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|-----------------|--|--|
| 90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib | Giass Cories Steel Hole Volume Hole Depth | Cones | | |
| Total No. of Fragmants: For TNT For Subject NS | Color: | | | |
| For Subject HE 3 inch HE, M42A1 [°] Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib | Principal Uses: Gelätinizer for nitrocellulose | | | |
| Tatal No. of Fragments: For TNT For Subject HE | Method of Looding: | | | |
| | Looding Density: gm/cc | | | |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Storege: Method | Liquiđ | | |
| Binst (Relative 's TNT): | Hazard Class (Quantity-Distance) | Class 9 | | |
| Air: Peak Pressure Impulse Energy | Compatibility Group Exudation | | | |
| Air, Confined: Impulse | Hydrolysis, \$ Acid: 10 days at 22°C 5 days at 60°C | 0.021 0.014 | | |
| Under Weter: Peak Pressure Impulse Energy | Solubility in Water, <u>gm/100 gm, at:</u> 25 ⁰ C 60 ⁰ C | <0.01 <0.015 | | |
| Underground: Peak Pressure Impulse Energy | Solubility, gm/100 gm, <u>et 25°C, in:</u> Ether 2:1 Ether:Alcohol Acetone <u>Heat of:</u> Combustion, cal/gm | 2407 | | |
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Glycerol Monolactate Trinitrate (GLIN) Liquid

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Preparation:

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Glycerol monolactate (GML) is prepared by heating a glycerol lactic acid mixture containing 4% excess lactic acid at 116°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 HNO₂/H₂SO₁ 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 bicarbonate solution, and again water-washed three 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-mitrogen content of 13.43% (theoretical 14.1% N). Another batch, prepared from GML obtained from glycerol-lactic acid containing 5.5% excess glycerol, had a mitrate-mitrogen 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 Fatert 456,525 and U. S. Patent 2,087,980).

Reference: 31

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

³¹See footnote 1, page 10.

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Glycol Dinitrate (GDN) Liquid

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| Composition: % | Molecular Weight: (C ₂ H ₄ N ₂ O ₆) | 152 |
|------------------------------------------------------------------|----------------------------------------------------------------------------------|---------------|
| C 15.8ONO2 | Oxygen Belance: | |
| | CO₂ % CO % | 0.0 21 |
| | | |
| N 18.4 CH ₂ | Density: gm/cc Liquid, 25°C | |
| | Meking Point: *C | -20 |
| C/H Ratio 0.092 | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: | Beiling Point: "C | |
| Bureau of Mines Apparatus, cm 4 (1 1b vt); 56 Sample Wt 20 mg | Refractive Index, ng | |
| Picatinny Arsenal Apparatus, in. | n | 1.4452 |
| Sample Wt, mg | 20 | 214496 |
| Friction Pendulum Test: | | |
| Steel Shoe | Vecuum Stability Test: cc/40 Hrs, at | |
| Fiber Shoe | 90°C | |
| | 100°C | |
| Rifle Builst Impact Test: Trials | 120°C | |
| ey, Explosions | 135°C | • |
| Explosions Partials | 150°C | |
| Burned | 200 Gram Bomb Sund Test: | |
| Unaffected | Sond, gm | |
| | | |
| Explasion Temperature: "C | Sansitivity to Initiation: | |
| Seconds, 0.1 (no cop used) | Minimum Detonating Charge, gr | n |
| l 5 Explodes - 257 | Mercury Fulminate | |
| 10 | Leod Azide | |
| 15 | Tetryi | |
| 20 | Bailistic Morter, % TNT: | |
| | Treuzi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dest Test: | |
| | Method | |
| 100°C Heet Test: | Condition | |
| % Loss, 1st 48 Hirs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | |
| Explosion in 100 Hrs | Brisance, % TNT | |
| | Detenstion Rate: | |
| Fiummability Indexs | Confinement | Class tube |
| An analytic of the second put a con | Condition | Liquid |
| Hygreedepleity: % 30°C, 90% RH 0.00 | Charge Diameter, Io. | 10 |
| Volatility: | Density, gm/cc | 1.485 |
| | Rote, meters/second | 7300 and 2050 |

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Glycol Dinitrate (GIN) Liquid

| Frequentation Yest: | Sheped Charge Effectiveness, THT = 100: |
|---------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectiki, Lot WC-91: Density, gm/cc Charge Wt, Ib | Glass Cones Steel Cones Hole Volume Hole Depth |
| Totel No. of Fragments: For TNT | Color: Yellow |
| For Subject HE 3 lach HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib | Principal Uses: Ingredient of nonfreezing dynamite |
| Tatel Ne. of Fregments: For TNT For Subject HE | Method of Loading: |
| | Loeding Denaity: gm/ca |
| Frequent Vesucity: ft/se: At 9 ft At 25½ ft | Storege: |
| Density, gm/cc | Method Liguid |
| Blues (Relative to TNT): | Hozard Class (Quantity-Distance) Class 9 |
| Ain Pask Pressure impuise Energy | Compatibility Group Exudation |
| Air, Confined: Impulse | Solubility in 1000 cc Water: Temp, ^o C Grams |
| Under Water: Peak Pressure | 15 6.2 20 6.8 50 9.2 |
| Impuise Energy | Viscosity, cantipoises: Fourp. 20°C 4.2 |
| Undurground: Pook Pressure Impulse Energy | Vapor Pressure: OC umm Mercury 0 0.0044 20 0.038 40 0.26 60 1.3 80 5.9 100 22.0 |
| | Heat of: Combustion, cal/gm 1764 Formation, cal/gm (b) 366 |

Glycol Dinitrate (GDN) Liquid

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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 sthylene, and ethylene chlorohydrin:

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

Origin:

1

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 made 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 (Mém poudr 16 (1911) p. 214). The principal physical properties of GDN were determined or recorded by Rinkenbach (Ref b).

References: 32

(a) Ph. Nacum, <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, <u>Application of the Vacuum Stability Test to Nitroglycerin and Nitro-</u> glycerin Explosives, PATR 1624, 27 August 1946.

32See footnote 1, page 10,

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| Composition: % | Molecular Weight: | 93 |
|----------------------------------------------------------------------|-------------------------------------------------------------|----------------|
| 70 RDX 45 TNT 30 | Oxygen Balence: CO ₂ % | -66 |
| Aluminum 20 | CO % | -36 |
| D-2 Wax 5 | Density: gm/cc Cast | 1.74 |
| Calcium Chloride, added 0.5 | Maiting Point: *C | |
| C/H Ratio | Freezing Paint: "C | |
| Impect Sansitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Beiling Point; *C | |
| Sample Wt 20 mg | Befractive Index, no | · · · |
| Ficatinny Arsenal Apparatus, in. (c) 14 Sample Wt, mg 18 | n | |
| Complet wething To | n 🐱 | |
| Friction Pendulum Test: | Vecuum Stability Test: | |
| Steel Shoe Unaffecter | | |
| Fiber Shoe | 90°C | |
| Rifle Sullet Impact Test: Trials (b) | 100°C | 0.47 |
| % | 120°C | |
| Explosions 80 | 135°C 150°C | |
| Partials | 150°C | |
| Burned | 200 Gram Samb Sand Test: | |
| Unaffected 20 | Sand, gm | 49.5 |
| Explosion Tempereture: "C (a) Seconds, 0.1 (no cap used) """ | Sensitivity to Initiation: Minimum Detonating Charge, gm | |
| 1 | Mercury Fulminate | |
| 5 610(min) (c) | Lead Azide | 0.20 |
| 10 | Tetryi | 0.10 |
| 15 | | |
| 20 | Bellistic Mortor, % TNT: (d) | 135 |
| 75°C International Heat Test: | Treuxi Test, % TNT: | |
| % Loss in 48 Hrs | Plete Dent Test: Method | |
| 100°C Heat Test: | Condition | |
| % Loss, 1st 48 Hrs 0.78 | Confined | |
| % Loss, 2nd 48 Hrs 0.00 | Density, gm/cc | |
| Explosion in 100 Hrs None | Brisance, % TNT | |
| Flammability Index: | Confinement | (a, b) None |
| Hygrescopicity: % 30°C, 95% EH, 7 days 2.4 | Condition | Cast |
| Hygrescepicity: % 30°C, 95% NH, 7 days 2. 71°C, 95% NH, 7 days 1. | in Churge Diumerer, in. | 1.0 |
| Veletility: | Density, gm/cc | 1.71 |
| | Rate, meters/second | 7191 |

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Booster Sensitivity Test: Decomposition Equation: Condition Oxygen, atoms/sec (Z/sec) Tetryi, gm ¹Heat, kilocolorie/mole Wax, in. for 50% Detonation (JH, kcal/mol) Wax, gm Temperature Range, *C Density, gm/cc Phose Hent af: Annier Plate Impact Test: 3972 Combustion, col/gm Explosion, cal/gm 923 60 mm Mortar Projectile: Gas Volume, cc/gm 733 50% Inert, Velocity, ft/sec Furmation, cal/gm **Aluminum Fineness** Fusion, cal/gm 18°C (b) 10.25 500-lb General Purpose Combe: (b) Specific Heet: cal/gm/*C Plate Thickness, inches 30°C 0.269 50°C 1 0.268 114 11% 1% **Burning Rate:** cin/sec Somb Dray Test: Thermal Conductivity: cal/sec/cm/*C 35°C (b) -3 1.10 x 10 T7, 2000-16 Semi-Anner-Plansing Somb vs Concrete: Max Safe Drop, ft Coefficient of Exponsion: Linear, <u>Al</u>/inch 000 35°C 70°C 40×10^{-4} 83 x 10⁻⁴ 131 x 10⁻⁴ 500-lb General Purpose Bomb vs Concrete: Height, ft Trials Hardness, Mohe' Scale: Unaffected Low Order Young's Modulars (b) High Order 9.0 x 10⁹ E', dynes/cm² 1.30 x 10⁵ E. Ib/inch² 1000-15 General Purpose Somb vs Concrete: 1.71 Density, gm/cc Height, ft Compressive Strength: Ib/inch² See below Triols Unaffected Low Order Vapor Pressure: ۰C mm Mercury High Order Compressive Strength: 1b/inch² 1083 Density, gm/cc Ultimate deformation, % 1.71 1.32

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| Fragmantation Test: | (b) | Shaped Charge Effectiveness, TNT = 1 | i30: |
|-------------------------------------------------------------------------------------|--------------|------------------------------------------------|---------------------------------------|
| 90 mm HE, M71 Projectile, Lut EGS-1-1 Density, ym/cc Charge Wt, Ib | 7: | Giass Cones Steel Hole Volume Hole Depth | Cones |
| Total No. of Fragments: For Composition B | 998 | Color: | Gray |
| For Subject HE For 80/20 Tritonal | 714 616 | Principal Uses: | HE charge |
| 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib | | | |
| Total No. of Fragments: Far TNT | | Method of Loeding: | Cast |
| for Subject HE | | Looding Density: gm/cc | 1.71 |
| Fragment Velocity: ft/sec At 9 ft At 25½ ft | | Storage: | · · · · · · · · · · · · · · · · · · · |
| Density, gm/cc | | Method | Dry |
| Blast (Relative to TNT); | (a) | Hazard Class (Quantity-Distance) | Class 9 |
| Aiv: 3.25" diameter sphere Peck Pressure Δ psi Catenary Impulse NFOC Pendulum | 25.4 19.8 | Compatibility Group Exudation | Group I |
| Energy | | | |
| Air, Confined: impulse | | | |
| Under Weter: Peak Pressure | | | |
| impulse Energy | | | |
| Underground: Peak Pressure Impulse Energy | | | |
| | | | |

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Effect of Altitude, Charge Diameter and Degree of Confinement on Detonation Velocity*

(Reference e)

| | | One-Inc | h Column | Two-Inch Column | |
|------------------------|-----------------------------|-----------------|-------------------|-----------------|-------------------|
| Explosive | Simulated Altitude, Feet | Confined D/S | Unconfined m/s | Confined m/s | Unconfined m/s |
| INT, | Ground | 6820 | 6720 | 6670 | 5270 |
| density, gm/cc 1.59 | 30,000 | 6660 | 6930(2) | 6610 | 6760(4) |
| | 60,000 | 6800 | - | 6520 | 6400(4) |
| | 90,000 | 6810 | 6720 | 6550 | 6610(1) |
| Average | : | 6798 | 6790 | 6588 | 6260 |
| н-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" 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 | Velocities a | at Various | Altitudes* | (e) |
|------------------|--------------|------------|------------|-----|
| | | | | |

| | | Simulated Altitude, Feet | | | |
|------------------------|----------------------------|--------------------------|----------------------|----------------------|----------------------|
| Explosive Cr | Charge Diameter, Inches | Ground m/s | <u>30,000</u> m/s | <u>60,000</u> m/s | <u>90,000</u> m/s |
| TNT, | 1 | 2940 | 2991 | 3119 | 2868 |
| density, gm/cc 1.51 | 2 | 3623 | 4191 | 5077 | 4980 |
| н-6, | 1 | 3461 | 3405 | 3467 | 3563 |
| density, gm/cc 1.71 | 2 | 4603 | 4726 | 4998 | 5288 |

"Outside diameter 2.54"; inside diameter 2.04"; length 7".

References:

See HBX-1; HBX-3 reference list.

Haleite (Ethylene Dinitramine) (EDNA)

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| $\begin{array}{c c} & 16.0 & H_2C - N \\ H & 4.0 & H \\ N & 37.3 & H \\ O & 42.7 & H_2C - N \\ C/H Ratio 0.066 & H \\ \end{array}$ | Oxygen Belance: -32 CC. % -10.5 Density. m/cc Crystal Decomposes 175+ Freezing Point: 'C Crystal | |
|------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------|
| N 37.3 0 42.7 $H_2C - N < V_2$ | Melting Point: "C Decomposes 175+ | |
| | | |
| | Freezing Point: "C | |
| | | |
| mpact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 48 | Bailing Point: "C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 14 Sample Wt, mg 17 | Refrective Index, ng ng ng | |
| riction Pandulum Test: | Vocuum Stability Test: | |
| Steel Shoe Unsificated | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | - 90°C - 100°C 0.5 | |
| lific Builet Impact Test: Trials | 120°C 1.5 | |
| % | 135°C | |
| Explosions O Partials 60 | 150°C 11+ | |
| Burned 20 | 200 Gram Bomb Sand Test: | |
| Unoffected 20 | Sand, gm 52.3 | |
| izplotian Temperature: *C | Sensitivity to Initiatian: | المزرجة محاقي |
| Seconds, 0.1 (no cap used) 265 | Minimum Détonating Charge, gm | |
| l 216 5 Decomposes 189 | Mercury Fulminate 0.21 | |
| 10 178 | Leod Azide 0.13 | |
| 15 173 | Tetryl | |
| 20 170 | Bellistic Mortor, % TNT: (a) 139 | |
| | Trount Test, % TNT: (b) 122 | |
| S*C International Host Yest: % Loss in 48 Hrs 0.01 | Plate Dent Test: (c) Mathod A | |
| 00°C Heat Test: | Condition Pressed | |
| % Loss, 1st 48 Hrs 0.2 | Confined Yes | |
| 96 Loss, 2nd 48 Hrs 0, 3 | Density, gm/cc 1.50 | |
| Explosion in 100 Hrs None | Brisance, % TNT 122 | الديالاستحداد |
| lemmebility index: 138 | Detenation Rate: Confinement Unconfi | |
| lygroszopiciły: % 0.01 | Condition Pressed Charge Diameter, in. 1,0 | |
| feistility: N11 | Density, gm/cc 1, 40 Rate, meters/second 7570 | |

Haleite (Ethylene Dinitramine) (EDNA)

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| Beaster Sensitivity Test: Condition | (d) Pressed | Decomposition Equation: (e) (e) (f) Oxygen, atoms/sec 10 ^{12.8} 10 ^{12.1} 10 ^{11.1} |
|--------------------------------------------|----------------------------------------|-------------------------------------------------------------------------------------------------------------------|
| | | (Z/sec) |
| Tetryl, gm Way in the 50% Determine | 100 2.09 | Heat, kilocalorie/mole 30.5 37.3 30.8 |
| Wax, in. for 50% Detonation | 2.09 | (14, kcal/mol) Temperature Range, *C 184-254 144-164 |
| Wax, gm | | |
| Density, gm/cc | 1.42 | Phose Liquid Solid Solid |
| Heat of: | | Armer Plate Impact Test: |
| Combustion, col/gm | 2477 | |
| Explosion, cal/gm | 1276 | 60 mm Morter Projectile: |
| Gas Volume, cc/gm | 905 | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | 134 | Aluminum Fineness |
| Fusion, cal/gm | | 500-lb General Purpose Bombs: |
| Specific Heet: col/gm/*C | | |
| | | Pinte Thickness, inches |
| | | 1 |
| | | 14 |
| | | 110 |
| | | 174 |
| Burning Rote: cm/sec | | ······································ |
| | ······································ | Bomb Drop Test: |
| Thermal Conductivity: col/sec/cm/*C | | T7, 2000-lb Semi-Armor-Piercing Bamb vs Concrets: |
| | | |
| Coefficient of Expansion: | | Max Safe Drop, ft |
| Linear, %/1C | | 500-lb General Purpose Bomà ve Concretus |
| Volume, %/*C | | Height, ft |
| | | Trials |
| Hardnass, Mahs' Scale: | | Unoffected |
| Young's Modulus: | | Low Order |
| E', dynes/cm ² | | High Order |
| | | |
| E, Ib/inch ² | | 1000-ib General Purpose Bemb vs Concrete: |
| Den lity, gm/cc | | |
| Compressive Strength: Ib/inch ² | | Triols |
| | | Unoffected |
| • • • • • • • • • • • • • • • • • • • | · · · · · · · · · · · · · · · · · · · | |
| Veper Pressure: C mm Mercury | | Low Order |
| C mm mercury | | High Order |
| | | |
| | | |
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Haleite (Et aylene Dinitramine) (EDNA)

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| Fragmentation Test: | Shaped Charge Effectiveness, TNT = 1 | 00: |
|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------|----------------|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc 1.61 Charge Wt, ib | Glass Cones Steel (Hale Volume Hole Depth | Cones |
| Total Na. of Fragmants: For TNF | Color: | White |
| For Subject HE 3 inch HE, M42A1 Projectile, Lot KC-5: <u>95/5 Halette/vax</u> Density, gm/cc <u>1.56</u> Charge Wt, lb | Principel Uses: | Booster |
| Total Ne. of Fragments: For TIT 514 For Subject HE 600 | Mothed of Louding: | Pressed |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Looding Density: gm/cc ps1 x 5 10 12 15 1.28 1.38 1.41 1.44 Storage: | 20 1.49 |
| Blast (Relative to TNT): Air: Peak Pressure | Method | Dry Class 9 |
| impulse Energy | Exudation | None |
| Air, Confined: Impulse | | |
| Under Water: Peak Pressure Impulse Energy Underground: | • | |
| Peak Pressure Ingulse Energy | | |
| | | |

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Haleite (Ethylene Dinitramine) (EDNA)

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Compatibility with Metals:

Dry - 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.

Wet - 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 | WL: |
|-----------------|--------|-------|---|----|-----|
| Habit | | | | | 8 |
| 1st plate | | | | | 55 |
| 2nd plate | | | | | 55 |
| Bi-pyramid | | | | | 71 |
| Bracydome | | | | | 66 |
| Sphenoid | | | | | 46 |

Solubility: gm/100 gm (%) of:

| Wa | ter | <u>A1</u> | cohol |
|-----------------------------|-------------------------------------|----------------------|------------------------------|
| °c | 1 | °c | Ź |
| 20 40 60 80 100 | 0.25 0.75 2.13 6.38 >20 | 20 40 60 78 | 1.00 2.46 5.29 10.4 |

Preparation:

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

$$CH_2O + HCN \rightarrow HO CH_2CH$$

(98% yield)
HO CH_2CN + NH₃ \rightarrow NH₂CH₂CN + H₂O
(82% yield)

 $MH_2CH_2CH + 2H_2 \rightarrow H_2N CH_2CH_3NH_2$ (88% yield)

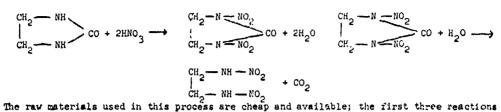
$$\begin{array}{c} CH_2 & H_2 \\ CH_2 & H_2 \end{array} + CO_2 \rightarrow \begin{array}{c} CH_2 & H_2 \\ CH_2 & H_2 \end{array} \right) CO + H_2 O$$

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Haleite (Ethylene Dinitramine) (EDNA)

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proceed smoothly, rapidly and in good yield (70% overall), and only the third requiren high pressures. The reaction of ethylenediamine with carbon dioxide at about 220°C and 220 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.

Ethyleneures is very easily nitrated, with strong nitric acid (923). At ordinary temperature, Haleite, immediately after solution in water at 95°C. Both the nitration and hydrolysis are practically quantitative.

Origin:

First described in 1877 by Franchimont and Klobbie (Rec trav chim 7, 17 and 244) but it was 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 ethylene given 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</u> of <u>Explosives</u>, <u>Part III</u> - <u>Miscellanecus</u> <u>Sensitivity Tests</u>; <u>Performance Tests</u>, <u>GGRD</u> Report No. 5746, 27 Tecember 1945.

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

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

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

(e) R. J. Finkelstein and G. Gamov, Theory of the Detonation Process, HAVORD Report No. 90-46, 20 April 1947.

(f) M. A. Cook and M. Taylor Abbeg, "Taothermal Decomposition of Explosives." University of Utsh, Ind Eng Chem (June 1956) pp. 1090-1095.

33See footnote 1, page 10,

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Haleite (Ethylene Dinitramine) (EDNA)

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

| 0 | 1 | 2 | 3 | 4 | 5 | <u>6</u> | <u>7</u> | 8 | 2 | |
|----------------------------------------------|----------------------|--------------------------------------|----------------------|---------------------|------------------------------|-------------|-------------------------------------|--------------------------------------|----------------------------------------------|--|
| 1200 1290 1360 1360 1400 1600 | 1231 1451 1651 | 1162 1232 1252 1352 1372 | 1113 1493 1923 | 414 1294 1434 | 1255 1325 1395 1885 | 726 1796 | 897 1737 1797 19 37 | 1198 1288 1378 1388 1838 | 1279 1319 1379 1469 1489 2179 | |

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| Composition: | | Molecular Weight: | 102 |
|---------------------------------------------------------------|------------------------|-------------------------------|------------------|
| RDX 40 | | Oxygen Balanze: | |
| TNT 38 | | CO. % | -68 |
| Aluminum 17 | | CO % | - 35 |
| D-2`Wax 5 | | Density: gm/cc Cast | 1.72 |
| Calcium Chloride, added 0.5 | | Molting Point: *C | |
| C/H Ratio | | Freezing Point: *C | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | | Boiling Point: *C | |
| Sample Wt 20 mg | | Refractive Index, ng | |
| Picatinny Arsenal Apparatus, in. | 16 | nü | |
| Sample Wt, mg | 21 | ns | |
| Friction Pendulum Test: (b) | | Vocuum Stability Test: | (•, b) |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | | 90°C | |
| | // \ | - 100°C | 0.47 |
| Rifle Bullet Impact Test: Trials | (b) | 120°C | 6.9 ⁰ |
| % Evolutions 73 | | 135°C | |
| Explosions 73 | | 150°C | 11+ |
| Portials | | | |
| Burned Upoffected 28 | | 200 Grem Bomb Sand Test: | 48.1 |
| Unaffected 28 | | Sand, gm | 40.1 |
| Explosion Temperature: *C | (a) | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | | Mercury Fulminote | |
| 5 430 | | Lead Azide | 0,20 |
| 10 | | Tetryi | 0.10 |
| 15 | | Bailistic Marter, % TNT: (2) | 1.33 |
| 20 | | - Treuzi Test, % TNT: | +)) |
| 75°C International Heat Test: | | Plate Daat Test: | |
| % Loss in 48 Hrs | | Method | |
| 100°C Heet Test: | (b) | Condition | |
| % Loss, 1st 48 Hrs | 0.058 | Confined | |
| | 0.00 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisance, % TNT | |
| · | | - Detanetian Rate: | (a, b) |
| Flammability Index: | | Confinement | None |
| and and and and and | A-110 | - Condition | Cast |
| Hygrescepicity: % 30°C, 95% RH, 7 71°C, 95% RH, 7 | days 2.98 days 1.13 | Charge Diameter, in. | 1.0 |
| | | - Density, gm/cc | 1.69 |
| Veletility: | | Rate, meters/second | 7224 |

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| Casefficient of Expansion:(b)Max Safe DrayCasefficient of Expansion:(b)Max Safe Dray $O^{0}C$ 46 x 10 ⁻¹⁴ 500-16 Genarel F $35^{0}C$ 95 x 10 ⁻¹⁴ Height, ft $70^{0}C$ 159 x 10 ⁻¹⁴ Height, ftHardness, Moha' Scale:UnaffectedYoung's Medulus:(b)E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc1.69Height, ftCompressive Strength: lb/inch ² See belowUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffected | tion: |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| Image ProductImage ProductWax, in. for 50% Detonation1.25Wax, gm1.73Density, gm/cc1.73Density, gm/cc9.25Sold mm Morter P50% Inert, VeSold mm Morter P114Density, gm/cc1Density, gm/cc1Density, gm/cc1Density, gm/cc1.65Density, gm/cc1.69Height, ftTrialsDensity, gm/cc1.69Height, ftTrialsDensity, gm/cc1.69Height, ftTrialsDensity, gm/cc1.69Height, ftTrialsUnotfectedCoorder1.69Height, ftTrialsUnotfected | 2 C |
| Wax, in. for 50% Detonation1.25($\Delta H, kcol/mol)$ Wax, gm1.73($\Delta H, kcol/mol)$ Wax, gm1.73($\Delta H, kcol/mol)$ Density, gm/cc1.73($\Delta H, kcol/mol)$ Heet ef:(b) $Armer Plete ImpactCombustion, cal/gm91960 mm Marter PGas Valuare, cc/gm50%Armer Plete ImpactFunction, cal/gm758Aluminum FinFusion, cal/gm758Aluminum FinFusion, cal/gm70°C9.25Specific Heet: cal/gm/*C(b)Plate Thicknet30°C0.26%130°C0.26%130°C0.26%130°C0.26%1Suming Rete:(b)14Coofficient of Exputation:(b)Linger, \Delta LAnchAc 10^{-1}_{L}0°C46 \times 10^{-1}_{L}35°C95 \times 10^{-3}T7, 2000-ib General PSoo-ib General PSoo-ib General PSoo-ib General PSoo-ib General PCoofficient of Exputation:(b)Linger, \Delta LAnchAc 10^{-1}_{L}0°C16 \times 10^{-1}_{L}70°C159 \times 10^{-5}Height, ftTrialsUnaffectedLow OrderYeung's Medulus:(b)E', dynes/cm21.49 \times 10^{-5}Density, gm/cc1.69Height, ftTrialsCompressive Strength: Ib/inch2See belowTrialsUnaffected$ | 'male |
| Density, gm/cc 1.73 PhaseHeat ef:(b)Combustion, cal/gm3802Explosion, cal/gm919Gas Valune, cc/gm 50% inert, VeFormation, cal/gm758Fusion, cal/gm758Fusion, cal/gm 758 Specific Heat: cal/gm/*C(b) $30^{\circ}C$ 0.249 $50^{\circ}C$ 0.249 Specific Heat: cal/gm/*C(b) $30^{\circ}C$ 0.26% $50^{\circ}C$ 0.26% 1114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 114 116 116 1160 116 1160 116 1160 <t< td=""><td></td></t<> | |
| Heat of:(b)Combustion, cal/gm3802Explosion, cal/gm919Gas Valuane, cc/gm50% inert, VeFormation, cal/gm758Fusion, cal/gm758Fusion, cal/gm758Specific Heet: cal/gm/*C(b) 30° C0.249 50° C0.26% 30° C0.97 x 10^{-3}Coofficient of Expansion:(b)Linear, $\Delta LAnch$ Max Safe Drop 0° C46 x 10^{-4} 35° C95 x 10^{-4} 70° C159 x 10^{-4}Height, ftTrialsUnaffectedLow OrderHigh Order1.69E, ib/inch ² 1.49 x 10^{-5}Density, gm/cc1.69Height, ftTrial'sUnaffectedUnaffected | ige, *C |
| Combustion, cal/gm3802Armer Flete ImpactExplosion, cal/gm91960 mm Morter PGas Volurne, cc/gm50%50% Inert, VeFormation, cal/gm758Aluminum FinFusion, cal/gm 75°C9.25502-ib General PSpecific Heet: cal/gm/*C(b)Plate Thicknet30°C0.26%130°C0.26%150°C0.26%111411411411411511450°C0.26%150°C0.26%150°C0.26%1114114114114115114114114115114114114115114114114114114114114114114115114114114114114114114114114114114114114114114115100-1b General P0°C159 x 10^-11000-1b General P1000-1b General P1001-1b General P1001-1b General P1001-1b General P1001-1b General P1001-1b General P1001-1b General | |
| Explosion, cal/gm919Gas Volume, cc/gm 50% Inert, VeFormation, cal/gm758Fusion, cal/gm758Fusion, cal/gm758Specifile Heet: cal/gm/*C(b) $30^{\circ}C$ 0.249 $50^{\circ}C$ 0.249 $50^{\circ}C$ 0.26° $30^{\circ}C$ 0.26° $50^{\circ}C$ 0.26° $30^{\circ}C$ 0.26° $30^{\circ}C$ 0.26° $50^{\circ}C$ 0.26° 114 114 114 116 $30^{\circ}C$ 0.26° $50^{\circ}C$ 0.26° $30^{\circ}C$ 0.26° 114 114 114 114 114 116 116 $30^{\circ}C$ $20^{\circ}C$ $20^{\circ}C$ $20^{\circ}C$ $20^{\circ}C$ $20^{\circ}C$ $20^{\circ}T$ $20^{\circ}C$ <td< td=""><td>Test:</td></td<> | Test: |
| Gas Volume, ce/gmGas Volume, ce/gm60 mm Marter PFormation, cal/gm758Fusion, cal/gm 78°C9.25Specific Heet: cal/gm/*C(b) $30^{\circ}C$ 0.249Specific Heet: cal/gm/*C(b) $30^{\circ}C$ 0.26%Specific Heet: cal/gm/*C1Specific Heet: cal/gm/*C(b) $30^{\circ}C$ 0.26%Specific Heet: cal/gm/*C0.26%Specific Heet: cal/gm/*C1Specific Heet: cal/gm/*C0.26%Specific Heet: cal/gm/*C0.26%Solution Rete:114Surming Rete:114Conflicient ef Expussion:(b)Coofficient ef Expussion:(b)Coofficient ef Expussion:(b)Lincar, ΔL anch46 x 10 ⁻¹⁴ $0^{\circ}C$ 95 x 10 ⁻⁴ Height, ftTriolsUnaffectedUnaffectedLow OrderHigh OrderYoung's Medulus:(b)E', dynes/cm ² 1.49 x 10 ⁻⁵ Density, gm/cc1.69Height, ftCompressive Strength: Ib/inch ² See below | |
| Formation, cal/gm758Aluminum FinFusion, cal/gm 78°C9.25502-15 General PSpecific Heet: cal/gm/*C(b)9.2530°C0.249Plate Thicknes50°C0.26%1114114132134Burning Rete: cm/sec(b)1Thermel Conductivity: cal/sec/cm/*C 35°C0.97 x 10*3T7, 2000-16 SemCoofficient of Expansion: 0°C(b)Max Safe DropLinear, dL/Anch 0°C46 x 10 ⁻¹⁴ 159 x 10*4S00-16 Genaral PHeight, ft TriolsTriolsUnaffected Low OrderYoung's Medulus: E, lb/inch?(b)1.49 x 10*5Density, gm/cc1.69Height, ft Trial's Unaffected | ojectile: |
| Fusion, cal/gm 75°C9.25Specific Heet: cal/gm/*C(b) $30°C$ 0.249Plate Thicknes $50°C$ 0.26%1 $50°C$ 0.97 x 10°377, 2000-ib SemCoofficient of Expension: $0°C$ (b)Max Safe DrayLingar, $\Delta LAnch$ 46 x 10°4500-ib Genarel H $0°C$ 95 x 10°4Height, ftTrialsUnaffectedLow OrderHardness, Mohs' Scele:(b)Low OrderYoung's Modulus: E', dynes/cm²10.3 x 10°F', dynes/cm²10.3 x 10°1000-ib GeneratDensity, gm/cc1.69Height, ftTrialsUnaffectedCompressive Strength: lb/inch²See below | locity, ft/sec |
| Specific Heet: cal/gm/*CSo2-ib General PSpecific Heet: cal/gm/*C(b)Plate Thicknest $30^{\circ}C$ 0.2491 $50^{\circ}C$ 0.26%1Surning Rete:0.26%1cm/secBamb Drop Test:1%Thermal Conductivity:(b)1.97 x 10^{-3}cal/sec/cm/*C35°C2.97 x 10^{-3}T7, 2000-ib SemCoofficient of Expansion:(b)Max Safe DropLingar, $\Delta LAnch$ 46 x 10 ⁻¹⁴ So0-ib Genarel P $0^{\circ}C$ 95 x 10^{-14}Height, ft $70^{\circ}C$ 159 x 10 ⁻¹⁴ Height, ftTrialsUnaffectedLow OrderHardness, Mohs' Scele:10.3 x 10 ⁹ High OrderYoung's Modulus:(b)Low OrderE, ib/inch ² 1.49 x 10 ⁻⁵ 1000-ib GeneratiDensity, gm/cc1.69Height, ftTrialsUnaffectedLow Order1.69 | ti\ess |
| Specific Heet: cal/gm/*C(b)30°C0.24950°C0.26%1141½1½8urning Rete: cm/sec(b)Cm/secBomb Drop Test:Thermel Conductivity: cal/sec/cm/*C 35°C0.97 x 10*3Coofficient of Expansion: 35°C(b)Coofficient of Expansion: 35°C(b)Coofficient of Expansion: 35°C(b)Linger, dLAnch 95 x 10*446 x 10*4 159 x 10*4Porc 70°C159 x 10*4Hardness, Mohs' Scele:(b)Young's Modulus: E', dynes/cm2(b)Linger, allow10.3 x 10 1.49 x 10*5Density, gm/cc1.69Height, ft TrialsCompressive Strength: Ib/inch2See belowCompressive Strength: Ib/inch2See below | |
| 30°C0.249Plate Thicknes50°C0.26%150°C0.26%11414141414141414141414141414141414141414141414141414141414141414141414141414141414141414141415100-15100-15100-15100-15100-15100-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-151000-1511000-151000-1511000-151000-1511000-151000-1511000-151100-1511000-151100-1511000-151100-1511000-151100-1511000-151100-1511000-151100-1511000-151100-15110 | urpose Sombs: |
| 30°C 0.249 $50^{\circ}C$ 0.26° $50^{\circ}C$ 0.26° 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 11_4 <t< td=""><td>s inches</td></t<> | s inches |
| 114 134 Burning Rete: cm/sec Bomb Drop Test: Thermel Conductivity: cal/sec/cm/*C 35°C 2.97 x 10 ⁻³ T7, 2000-ib Sem Coofficient of Expansion: (b) Linear, &&Anch 0°C 35°C 70°C 159 x 10 ⁻⁴ Height, ft Trials Unaffected Low Order High Order 2, dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² Density, gm/cc Log Compressive Strength: lb/inch ² See below | •, |
| 11/211/2Burning Rote: cm/secConstantivity: cal/sec/cm/*C 35°C(b) 2.97 x 10-3Tr, 2000-lb SemCoofficient of Expansion: O°C 35°C(b) 2.97 x 10-3Coofficient of Expansion: O°C 35°C(b) 95 x 10-4Max Safe Dray 500-lb Genaral # Height, ftTr, 2000-lb SemOofficient of Expansion: O°C 35°C(b)Max Safe Dray 500-lb Genaral # Height, ftTrials UnaffectedUnaffected Low Order High OrderTool-1b General Unaffected Low Order High OrderTool-1b General High OrderTool-1b General High OrderTool-1b General High OrderTool-1b General Unaffected | |
| Burning Rete: cm/sec Image: | |
| Burning Rete: cm/sec Bomb Drop Test: Thermel Conductivity: cal/sec/cm/*C 35°C 0.97 x 10 ⁻³ T7, 2000-ib Sem Coofficient of Expansion: (b) Linear, dLAnch 46 x 10 ⁻¹ / ₁ 0°C 95 x 10 ⁻¹ / ₁ 70°C 159 x 10 ⁻¹ / ₁ Height, ft Trials Unoffected Low Order Young's Modulus: (b) E', dynes/cm ² 10.3 x 10 ⁹ Density, gm/cc 1.69 Height, ft Trials Unoffected Low Order Height, ft Trials Unoffected Low Order High Order 1.69 Height, ft Trials Unoffected Low Order High Order 1.69 Height, ft Trials Unoffected Unoffected | |
| cm/secBomb Drop Test:Thermel Conductivity: cal/sec/cm/*C 35°C(b) 0.97 x 10-3T7, 2000-ib SemCoofficient of Expansion: O°C(b)T7, 2000-ib SemCoofficient of Expansion: O°C(b)T7, 2000-ib SemCoofficient of Expansion: O°C(b)T7, 2000-ib SemCoofficient of Expansion: O°C(b)T7, 2000-ib SemCoofficient of Expansion: O°COT7, 2000-ib SemCoofficient of Expansion: O°COSol-Ib Gonarel IIOO-Ib Gonarel IIOO-Ib Gonarel IIOO-Ib Gonarel IITrialsUnoffectedLow OrderHeight, ftTrialsUnoffectedLow OrderHigh OrderTool-Ib Gonarel IIOO-Ib Gonarel IITool-Ib Gonarel IIOo-Ib Gonarel IICompressive Strength: Ib/inch ² Ioo-Ib Gonarel IICompressive Strength: Ib/inch ² See belowTrialsUnoffectedLow OrderHigh OrderIoo-Ib Gonarel IICompressive | |
| Bomb Drop Test:Thermel Conductivity:(b)cal/sec/cm/*C 35°C2.97 x 10*3Coofficient of Expansion:(b)Linear, &&Anch46 x 10*40°C95 x 10*435°C95 x 10*470°C159 x 10*4Height, ftTrialsWardness, Mohs' Scele:Young's Medulue:(b)E', dynes/cm²Density, gm/ccLineirCompressive Strength: Ib/inch²See belowTrialsUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffectedUnaffected | |
| Coofficient of Expansion:(b)Max Safe DrayLinear, &&Anch46 x 10 ⁻⁴ 500-16 Genaral #0°C95 x 10 ⁻⁴ 500-16 Genaral #35°C95 x 10 ⁻⁴ Height, ft70°C159 x 10 ⁻⁴ TrialsHardness, Mohs' Scele:UnaffectedYoung's Medulue:(b)E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc1.69Height, ftCompressive Strength: lb/inch ² See belowUnaffected | |
| Coofficient of Expansion:(b)Max Safe DrayLinear, &&Anch46 x 10 ⁻⁴ 500-16 Genaral #0°C95 x 10 ⁻⁴ 500-16 Genaral #35°C95 x 10 ⁻⁴ Height, ft70°C159 x 10 ⁻⁴ TrialsHardness, Mohs' Scele:UnaffectedYoung's Medulue:(b)E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc1.69Height, ftCompressive Strength: lb/inch ² See belowUnaffected | |
| Linear, & LAinch 46 x 10 ⁻¹ / ₋₁ 500-1b Genaral F 0°C 95 x 10 ⁻¹ / ₋₁ Height, ft 35°C 95 x 10 ⁻¹ / ₋₁ Height, ft 70°C 159 x 10 ⁻¹ / ₋₁ Height, ft Hardness, Moha' Scale: Unaffected Young's Modulus: (b) Low Order E', dynes/cm ² 10.3 x 10 ⁹ High Order Density, gm/cc 1.69 Height, ft Compressive Strength: 1b/inch ² See below Trials | l-Armor-Plercing Bamb vs Concret |
| Linear, & & Anch O'C 35 ^o C 70 ^o C Young's Medulue: E', dynes/cm ² E, lb/inch ² Compressive Strength: lb/inch ² 46 x 10 ⁻⁴ 95 x 10 ⁻⁴ Trials Unaffected Low Order 1.49 x 10 ⁻⁵ 1000-lb General Height, ft Trials Unaffected Low Order High Order Height, ft Trials Unaffected Low Order High Order Height, ft Trials Unaffected Low Order High Order Height, ft Trials Unaffected Unaffected Unaffected Unaffected Unaffected Unaffected Unaffected Unaffected Unaffected Unaffected Unaffected Unaffected | o, ft |
| O°C 46 x 10 ⁻¹ / ₋₁ 35°C 95 x 10 ⁻¹ / ₋₁ Trials 159 x 10 ⁻¹ / ₋₁ Height, ft Trials Unaffected Low Order Young's Medulus: (b) E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc 1.69 Height, ft Trials Compressive Strength: lb/inch ² See below | urpesa Bomb vs Concrate: |
| Tobal Trais Hardness, Moha' Scale: Triais Young's Modulus: (b) E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc 1.69 Height, ft Compressive Strength: lb/inch ² See below | |
| Hardness, Mohs' Scale: Trials Young's Modulus: (b) E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc 1.69 Height, ft Compressive Strength: lb/inch ² See below Trials Unaffected Unaffected | |
| Hardness, Mohs' Scale: Unaffected Young's Medulus: (b) E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc 1.69 Height, ft Compressive Strength: lb/inch ² See below Trials Unaffected | |
| Young's Modulus:(b)Low OrderE', dynes/cm²10.3 x 109High OrderE, lb/inch²1.49 x 10^51000-lb GeneralDensity, gm/cc1.69Height, ftCompressive Strength: lb/inch²See belowTrialsUnaffectedUnaffected | |
| Young's Modulus: (b) E', dynes/cm ² 10.3 x 10 ⁹ E, lb/inch ² 1.49 x 10 ⁻⁵ Density, gm/cc 1.69 Heigh Order Tool-16 General Compressive Strength: lb/inch ² See below Trials Unaffected | |
| E', dynes/cm ² E, lb/inch ² Density, gm/cc Compressive Strength: lb/inch ² See below Unaffected | |
| Density, gm/cc 1.69 Height, ft Compressive Strength: Ib/inch ² See below Triats Unaffected | |
| Density, gm/cc 1.69 Height, ft Compressive Strength: Ib/inch ² See below Triats Unaffected | Purpose Bomb vs Concrete: |
| Compressive Strength: Ib/inch ² See below Trials Unaffected | • |
| Unaffected | |
| | |
| Vanag Brassura: Low Order | |
| *C mm Moreum | |
| | |
| Compressive Strength: 1b/inch ² 1303 Density, gm/cc 1.69 | |
| Ultimate deformation, % 1.38 | |

AMCP 706-177

HBX-1

| Fragmentation Test: | (b) | Shaped Charge Effectiveness, TNT == 1 | 00: |
|-------------------------------------------------------------------------------------------------------------------|--------------|--------------------------------------------------|-----------|
| 90 mm HE, M71 Projectile, Let EGS-1- Density, gm/cc Charge Wt, Ib | 17: | Glass Cones Steel (Hole Volume Hole Depth | Cones |
| Total No. of Fragments: For Composition B | 9 9 8 | Cələr: | Cray |
| For Subject HE For 80/20 Tritonal 3 inch HE, M42A1 Frojectile, Lot XC-S: Density, gm/uc Charge Wt, Ib | 910 616 | Principal Uses: | HE charge |
| Total No. of Fragments: For TNT For Subject HE | | Method af Loeding: | Cast |
| | <u></u> | Looding Density: gm/cc | 1.69 |
| Fragment Velocity: ft/sec At 9 ft At 251/2 ft | | Sterega: | |
| Density, gm/cc | | Method | Dry |
| Blast (Relative to TNT): | (A) | Hazard Class (Quantity-Distance) | Class 9 |
| Ale: 3.25" diameter sphere Peak Pressure & psi Catenary | 24.7 | Compatibility Group | Group I |
| impuise NFOC Pendulum Energy | 19.6 | Exudation | None |
| Air, Confined: Impulse | | | |
| Under Weter: Peak Pressure | | | |
| Impul se | | | |
| Energy | | 4 | |
| Underground: Poak Pressure | | | |
| Impulse | | | |
| Energy | | | |
| | | | |

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<u>HBX-3</u>

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| Composition: % | | | Melecular Weight: | | 64 |
|------------------------------------------------------------------------|---------|-------------|----------------------------------|-------|-----------------------------------------|
| % PDX | 31 | | Oxygen Belence: | | |
| INI | 29 | | CO, % | | -75 |
| Aluminum | 35 | | CO % | | -49 |
| D-2 Wax | 5 | | Density: gm/cc | Cast | 1.84 |
| Calcium Chloride, | • | | Melting Point: *C | ····· | |
| | 0.5 | • | | | |
| C/H Ratio | | | Freezing Point: "C | | |
| Impact Sansièivity, 2 Kg Wt: Bureau of Mines Apparatus, | cm | | Boiling Point: "C | | ***** |
| Sample Wt 20 mg | | | Refractive Index, n ^o | - | |
| Picatinny Arsenal Apparatus Sample Wt, mg | s, in, | 15 23 | ns | | |
| Jumple Wit, Ing | | £0 | . n _M | | |
| Friction Pendulum Test: | | | Vecuum Stability Test: | | (a, b) |
| Steel Shoe | | Unaffected | cc/40 Hrs, et | | (=, 0) |
| Fiber Shoe | | | 90°C | | **** |
| m1/1. S. H. L | | (b) | - 100°C | | 0.45 |
| Rifle Bullet Impact Test: 7 | rials | (6) | 120°C | | |
| Explosions | % 78 | | 135°C | | |
| Partials | | | 150°C | | |
| Burned | | | 200 Gram Bomb Sand Test: | | (Ն) |
| Unaffected | 22 | | Sand, gm | | 44.9 |
| Explosion Temporature: | ·c | (4) | Sensitivity to Initiation: | | |
| Seconds, 0.1 (no cop used) | | | Minimum Detonating Charge | i, gm | |
| 1 5 | 500 | | Mercury Fulminate | | |
| 10 | 200 | | Lead Azide | | 0.20 |
| 15 | | | Tetryl | | 0.10 |
| 20 | | | Bellistie Morter, % TNT: | (d) | 2.11 |
| | | | Trousi Test, % TNT: | | # * # * # * # * * * * * * * * * * * * * |
| 75°C International Heat Tase: % Loss in 48 Hrs | | | Flate Dant Test: | ····· | |
| | | | Method | | |
| 100°C Heat Test; | | (b) | Condition | | |
| % Loss, 1st 48 Hrs | | 0.70 | Confined | | |
| % Loss, 2nd 48 Hrs | | 0,00 | Density, gm/cc | | |
| Explosion in 100 Hrs | | None | Brisunce, % TNT | | |
| P4 4 141. 4 4 | | | - Detenation Rutu: | | (a, b) |
| Flammability Index: | | | Confinement | | None |
| Hygroscopicity: % 30°C, 959 | RH. | 7 days 2.01 | - Condition | | Cast |
| (b) 71°C, 959 | RH, | 7 days 0.31 | Charge Diameter, in. | | 1.0 |
| Velatility: | | | Density, gm/cc | | 1.81 |
| · •·•· | | | Rate, meters/second | | 6917 |

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HBX-3

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A Carton Sector

| Booster Sensitivity Test: Condition | | Decomposition Equation: Oxygen, atoms/sec |
|---------------------------------------------------------------------|---------------------------------------------------------------------------------------------|---------------------------------------------------|
| | | (Z/sec) |
| Tetryl, gm | | Heat, kilocolorie/mola |
| Wax, in. for 50% Detonation | | (AH, kcal/mol) |
| Wax, gm | | Temperature Range, *C |
| Density, gm/cc | | Phase |
| Heat of: | (b) 4495 | Armor Plate Impact Test: |
| Combustion, cal/gm | 877 | |
| Explosion, cal/gm | 011 | 60 mm Mortar Projectile: |
| Gas Volume, cc/gm | 1.45 | 50% Inert, Valocity, ft/sec |
| Formation, cal/gm | 491 | Aluminum Fineness |
| Fusion, cal/gm | 9.30 | 500-lb General Purposa Bamba: |
| Specific Heat: cal/gm/*C | | |
| 30°C | 0.254 | Plate Thickness, inches |
| 50 ⁰ 0 | 0.254 | 1 |
| | | 134 |
| | | 11/2 |
| | | 194 |
| Burning Rate: cm/sec | | |
| | | Somb Drop Test: |
| Thermal Conductivity: cal/sec/cm/°C 35°C | (b) 1.70 x 10 ⁻³ | T7, 2000-16 Semi-Armer-Piercing Bomb vs Concrete: |
| Coefficient of Expension: | (७) | Max Safe Drop, ft |
| Lineor, AL/inch | | 500-là General Purpose Bomb vs Concrete: |
| 0°C | 40 x 10 4 | Journa Canarar Farpene Bomb Ve Cancrete; |
| 35°C 70°C | $\begin{array}{c} 40 \times 10^{-1} \\ 83 \times 10^{-1} \\ 130 \times 10^{-1} \end{array}$ | Height, ft |
| 70°C | 130 x 10 | Triois |
| Hardness, Mohs' Scale: | | Unoffected |
| | | Low Order |
| Young's Modulus: | (७) | High Order |
| E', dynes/cm² | 11.5 × 10 ⁹ | |
| E, 1b/inch ² | 1.67 x 10 ⁵ | 1000-lb General Purpose Bomb vs Concrets: |
| Diensity, gm/cc | 1.81 | |
| Company Company L. H. H. H. | Can helow | Height, ft |
| Compressive Strength: Ib/inch ² | See below | Trials |
| | | Unaffected |
| Vapor Fressure: C mm Mercury | | Low Order High Order |
| | 1610 | |
| <u>Compressive Strength:</u> 1b/inch ² Density, gm/cc | 1.81 | |
| Ultimate deformation, 5 | 1.37 | |
| | | |

| regmentation Test: | | Shaped Charge Effectiveness, TNT == 1 | 100: |
|----------------------------------------|------------|---------------------------------------|-----------|
| 90 mm HE, M71 Projectile, Let BGS-1-17 | t: | Glass Cones Steel | Cones |
| Density, gm/cc | | Hole Volume | |
| Charge Wt, Ib | | Hole Depth | |
| Total No. of Fragments: | | Coler: | Grey |
| For Composition B | 998 | Comri | Gray |
| For Subject HE For 80/20 Tritonal | 476 616 | Principal Uses: | HE charge |
| 3 inch HE, M42A1 Projectile, Let KC-5: | | | |
| Density, gm/cc | | | |
| Charge Wt, Ib | | | |
| Total Nu. of Fragments: For TNT | | Method of Loading: | Cast |
| For Subject HE, | | Leading Banaltan and /co | 1.81 |
| agment Velocity: ft/sec | | Loading Density: gm/cc | 1.01 |
| At 9 ft At 25½ ft | | Storege: | |
| Density, gm/cc | | | |
| | | Method | Dry |
| est (Relative to TNT). | (a) | Hazard Class (Quantity-Distance) | Class 9 |
| Air: 3.25" diameter sphere | | Compatibility Group | Group I |
| Peak Pressure 🛆 psi Catenary | 25.5 | | |
| impulse NFOC Pendulum | 20.6 | Exudation | None |
| Energy | | | |
| Air, Confined: Impulse | | | |
| Under Water: Peak Preisure | | | |
| Impulse | | | |
| Energy | | | |
| Underground: Peak Pressure | | | |
| Impulse | | | |
| Energy | | | |
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HBX-1; HEX-3

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| | Moisture, | Acidity, | 100°C Vac | | Hygrosco 959 | picity, % |
|--------------------------|-----------|-------------|-----------|-------|-----------------|-----------|
| Explosive Composition | 2 | 2 | cc gas | Hours | | RH |
| | | | | | 30°C | 71°C |
| Standard HBX-1 | 0.73 | 0.011 | 0.47 | 40 | +2.98 | +1.13 |
| +0.2% moisture | , - | | 0.68 | 40 | | - |
| +0.4% moisture | | • | 0.62 | 40 | | |
| +0.6% moisture | 1 | | 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 | | 1 | 0.23 | 40 | | |
| +0.6% moisture | | ; ; [| 0.27 | 40 | | |
| HBX-1 with silics gel | 0.06 | 0.031 | 0.73 | 40 | +0.08 | +0.04 |
| | | | | 1.0 | | |
| Standard HBX-3 | 0.54 | i 0.012 | 0.45 | 40 | +2.01 | +0.31 |
| +0.2% moisture | | • | 0.47 | 40 | | |
| +0.4% moisture | | ı | 0.43 | 40 | | |
| +0.6% moisture | | | 0.41 | 40 | | |
| HBX-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 | | |
| HBX-3 with silica gel | 0.04 | 0.100 | 0.45 | 40 | +0.09 | +0.05 |
| Standard H-6 | 0.71 | 0.017 | 0.47 | 40 | +2.01 | +1.77 |
| +0.2% moisture | 0.11 | 0.011 | 0.88 | 40 | TEIVI | 471 () |
| +0.4% moisture | | | 0.63 | 40 | | |
| +0.6% moisture | | | 0.65 | 40 | | |
| | | | | | | |
| H-6 without CaCl, | 0.03 | 0.082 | 0.40 | 40 | -0.06 | -0.25 |
| +0.2% moisture | - | | 0.10 | 40 | | • |
| +0.4% moisture | | | C.25 | 40 | | |
| +0.6% moisture | | | 0.23 | 40 | | |
| H-6 with silics gel | 0.05 | 0.028 | 0.43 | 40 | +0.09 | +0.06 |

The Stability of HBX Compositions Made With and Without Desiccants and Containing Added Molature *

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

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HBX-1; HBX-3

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Preparation:

HEX explosive mixtures are prepared by melting TNT in a steam-jacketed melt kettle equipped with a mechanical stirrer. Water-wet RDX 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 84% paraffin and other waxes, 14% nitrocellulose and 2% lecithin. The mixture is cooled from approximately 95° to 100° C to a temperature considered suitable for casting (the lowest practicable pour temperature). HEX can also be made by adding the calculated amcunt of TNT to Composition B to obtain 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 Torpex II, for high blast explosive applications.

References: 34

(a) O. E. Sheffield, <u>Blast Properties of Explosives Containing Aluminum or Other Metal</u> <u>Additives</u>, PATR No. 2353, November 1956.

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

(c) 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.

(d) S. R. Walton, Report on the Program to Develop an Improved HBX-Type Explosive, NAVORD 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 Fragment Velocity Determinations of Varied Explosive Systems</u> <u>and Conditions</u>, <u>National Northern Corporation Final Summery Report NNC-F-13</u>, February 1958 (Contract DAI-19-020-501-ORD-(P)-58).

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

³⁴See [cotnote 1, page 10.

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<u>HEX-24</u>

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| Composition: | | Malacular Weight: | 47.6 |
|--------------------------------------------------|------------|-------------------------------------------------|-------------------------------------------------|
| Potassium Ferchlorate | 32 | Ouygon Belence: |) |
| (17 microns) | 48 | CO, % CO % | -42 |
| Aluminum, atomized (20 microns) | 40 | | - 34 |
| RDX (through 325 mesh) | 16 | Density on/cc Apparent Pressed at 20,000 psi | 1.39 2.1 |
| Asphaltum (through 100 mesh) | λ ι | Melting Point: *C | |
| C/N Ratio | | Freezing Paint: *C | |
| Impact Sanditivity, 3 Kg Wt: | | Beiling Point: *C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | | Refrective Index, no | الا الله مسترين الأكريسية مستوريني . |
| Picatinny Arsenal Apparatus, in. | 16 | | |
| Sample Wt, mg | 24 | nä | |
| | | ាដ្ឋ | |
| Friction Pandulum Test: | | Vacuum Stability Test: | |
| Steel Shoe | Detonates | cc/40 His, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifle Bullet Impact Yest: Trials | | - 100.0 | 1.25 |
| • | | 120.0 | |
| % Explosions | | 135*C | |
| Portials | | 150°C | |
| Burned | | 200 Gran Bomb Sauri Test: | |
| Unaffected | | Sand, gm | 12-5 |
| Explosion Tomperature: 'C | | Sunsitivity to Initiations | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | | Mercury Fulminate | |
| 5 520 | | Leod Azide | 0.20 |
| 10 | | Tatryl | 0.25 |
|)5 | | Ballistic Mortac, % THT: | |
| 20 | | Treusl Yest, % TNT: | |
| 75'C International Heat Test: | | | |
| % Loss in 48 Hrs | | Plate Dant Tast: Method | |
| 100'C Heat Yost: | | Condition | |
| % Loss, 1st 48 Hrs | 0.15 | Confined | |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/cc | |
| Explosion in 169 Hrs | lione | Brisunce, % TNT | وسريون وسريون والم |
| Flammability Indax: | | Detenstion Rate: Confinement | |
| | | - Condition | |
| Hygrascopicity: % | llone | Charge Dlameter, in. | |
| | | Density, gm/cc | |

| | HEX-24 AMCP 70 | /6-1 : |
|-----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|---------------|
| Fregmentation Test: | Shaped Chargo Effectiveness, TNT = 100: | <u> </u> |
| 90 mm HE, M71 Projectile, Lat WC-91: | Glass Cones Steel Cones | |
| Density, gm/: c | Hole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total No. of Fragments: | Celer: Grey | |
| For TNT | | |
| For Subject HE | Principel Uses: HE filler for small calibe | |
| Stude ME MARAN Burlandle Law MC R. | Principel Uses: HE filler for small calibe projectiles | ir |
| 3 inch HE, M42A1 Projectile, Let KC-5: | P | |
| Density, gm/cc Charge Wt, Ib | | |
| | | |
| Total Na. of Fragments: | Method of Looding: Pressed | |
| For TNT | | |
| For Subject HE | | |
| و بالمحمد المحمد الم | Looding Density: gm/cc | |
| Fragmant Valacity: ft/sec | Pressed at 20,000 psi 2.1 | |
| At 9 ft At 25½ ft | Sterege: | |
| Density, gm/cc | | |
| | Method Dry | |
| Biast (Relative to TNT): | Hazard Class (Quantity-Distance) | |
| ٠ ٨١ | Compatibility Group | |
| Ain Peak Pressure | | |
| Impulse | Exudotion None | |
| Energy | | |
| | Static Tests: | |
| Air, Confined: | 20 mm T215El Projectile: | |
| Impulse | PA Peak Pressure, pui 55 MFOC 20" Blast Cube 44 | |
| Under Water: | APO 24" Blast Cube 44 | |
| Peak Pressure | Static Tests; | |
| Impulse | 20 mm M97 Projectile: | |
| Energy | | трех |
| | Foxboro pai 19 12.4 1 Catenary pai 46 | 3.0 |
| Underground: Peak Pressure | | |
| Impulse | APG 24" I ist Cube 36 24 | 32 |
| Energy | Hest of: | |
| Plame Temperature, ^O K 25 | | |
| Activation Energy, kcal 20. | 4 Explosion, cal/gm 1858 | |
| Temp, °C 450 to 5' | | |
| Specific reaction rate, k 1.64 x 10 | -5 | |
| | | |

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| Composition: | Moleculer Weight: | 47.6 |
|------------------------------------------------------------------------------------|-------------------------------------------------------------|------------|
| % Potassium Perchlorate 32 (17 microns) Aluminum, flaked (1 micron) 48 | Oxygen Balance: CO ₂ % CO % | -42 -34 |
| RDX (through 325 mesh) 16 Arphaltum (through 100 mesh) 4 | Density: gm/cc Apperent Pressed at 20,000 psi | 0.69 |
| | Melting Point: "C | |
| C/H Ratio | Freezing Point: *C | |
| Impect Sensitivity, 2 Kg Wt: Bureou of Mines Apparatus, cm | Boiling Point: "C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg | Refractive Index, nº Mis Nº | |
| Friction Pendulum Test: Steel Shoe Partially detonates Fiber Shoe Unaffected | Vocuum Stability Test: cc/40 Hrs, at 90°C | |
| Rifle Bullet Impact Test: Trials % Explosions | - 100°C 120°C 135°C | 1.52 |
| Partials Burned Unoffected | 150°C 209 Grem Bomb Sand Test: Sand, gm | 23.7 |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) | Sensitivity to Initiation: Minimum Detonating Charge, gm | |
| 1 5 545 | Mercury Fulminate Lead Azide | |
| 10 | ietryl | 0.20 |
| 15 20 | Ballistic Martur, % TNT: | |
| | Treuxi Test, % TNT: | - 'i |
| 75°C International Heat Test: % 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 Brisonce, % TNT | |
| Explosion in 100 Hrs | | |
| Flammability Index: | - Detension Rete: Confinement | |
| Hygroscopicity: % | - Candition Charge Diamater, in. | |
| Voletility: | Density, gm/cc | |

HEX-48 Shaped Charge Effectiveness, THT = 100: **Fragmentation Test:** 90 mm HE, M71 Projectile, Lot WC-91: Glass Cones Steel Cones Hole Volume Density, gm/cc Hole Depth Charge Wt, Ib ١ Total No. of Fragments: Coler: Gray For TNT For Subject HE Principal Uses; HE filler for small caliber projectiles 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib Total No. of Fregments: Method of Londing: Pressed For TNT For Subject HE Loading Density: gm/cc Pressed at 20,000 pai 1.62 Fragment Velocity: ft/sec At 9 ft At 251g ft Storage: Density, gm/cc Dry Method Hazard Class (Quantity-Distance) Blast (Relative to TNT); **Compatibility Group** Air: Peak Pressure Exudation None Impulse Energy <u>Static Tests:</u> 20 mm T21551 Projectile: Air, Confined: PA Peak Pressure, pal 1700 20" Plast Cite AP7 24" Blast Cube T? 45 42 Impulse Under Water: Static Testa: 20 mm NO? Projectile: **Peak Pressure** Impulse HEX-13 7.T 2.8 29 Tetr: Energy Fostoro psi 17.3 3.9 28 Caterary psi 43 Iuration, microsec 517 APG 24" Blast Oube 29 Underground: 560 530 10 Peak Pressure Impulse Heat of: Energy Flame temperature, ox 2342 Compution, cs1/gm 4119 Explosion, cal/gm 1735 Nextworlds George, kcel 25.4 Gas Volume, cc/gm 200 lemp, "d "pecific reaction 450 to 470 7.54 x 10⁻⁶ rate, k

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AMCP 706-177

HEX-48

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Cook-Off Tests: (c)

20 mm T215El HEX-48 Loaded Projectiles With Dye-Costed RDX Top-Off

| Projectile No. | Cut-Off Temp. °C | Cook-Off |
|----------------|------------------|-----------|
| l | 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 650-1300 | | |
|------------|--------|----------------|--------------------------------------------------------|--------|--------|
| Projectile | Filler | Altitude, Feet | 0.020" | 0.040" | 0.051" |
| T215E1 | HEX-48 | Ground | 352 | 264 | 282 |
| | | 60,000 | ' 676 | 432 | 398 |
| T282E1 | MOX-2B | Ground | 634 | 290 | 235 |
| 1 | • | 60,000 | 807 | 367 | 250 |
| EDG8 Mod 0 | 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 24 ST-3 aluminum panels occurred with the projectile nose always pointed toward C^o and the base toward 180° .

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

HEX-24; HEX-48

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Preparation:

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

An alternate procedure for LOO to 200 gram batches used a "Cradle-Roll" mixing device. This device consisted of a balf-barrel type contriner constructed of wood and lined with an electrical conductive material. A plastic roll was sllowed 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:

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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 Picatiuny Arsenal developed a high capacity filler for 20 m projectiles consisting of 85/10/5 RDX/aluminum/desensitizer which was more poverful than standard tetryl filler. However, in comparison with MOX type explosives, there was little doubt as to the superior performance of the MOX mixture. HEX (high energy explosive) mixtures were developed at Picatinny Arsenal in 1953 (Ref a) as superior high blast compositions suitable for use in small caliber projectiles.

References: 35

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

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

(c) National Northern Corporation, Letter from Dr. C. M. Seffer, Jr., to Commanding Officer, Picstinny Arsenal, 12 June 1957.

³⁵See footnote 1, page 10.

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

| Camposition: % Q O | Molecular Weight: (C14H5:2014) | |
|----------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------|
| % 0 0 0 c 33.0 c c H 1.2 NH NH | Oxygen Bulance: CO. % CO % | -53.4 - 9.4 |
| N 21.9 021- NO2 02N NO2 | Density: gm/cc | |
| $ \begin{array}{c} N & 21.9 & 0_2 \\ 0 & 43.9 \end{array} $ | Melting Point: "C Decomposes | 302 |
| C/H Ratio 0.797 102 102 | Freezing Point: 'C | <u></u> |
| Impact Sen-itivity, 2 Ke Wt: | Boiking Point: "C | |
| Bureau r f Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 15 Sample Wt, mg , 12 | Refractive Index, n ₂₀ n ₂₅ n ₂₆ | |
| Friction Pendulum Tast: Steel Shoe Unaffected Fiber Shoe Unaffected | Vecuum Stability Test: cc/40 Hrs, at 90°C 100°C | |
| Rifle Bullet Impact Test: Trials % Explosions Partials | 120 C 135 C 150 C | 0.40 |
| Burned Unaffected | 200 Grem Bamb Sand Test: Sand, gm | 52.1 |
| Explosion Temperature: 'C Seconds, 0.1 (no cap used) I 5 392 10 15 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercuzy Fulminate Lead Azide Tetryl | 0.30 0.25 |
| 20 | Ballistic Mortan, % THT: | |
| 75°C International Heat Test: | Trouzi Test, % TNT: | |
| % Loss in 48 Hrs | Plate Dant Yest: Method | |
| 100°C Hect Test: | Condition | |
| ab Loss, 1st 48 Hrs 0.07 | Confined | |
| % Loss, 2nd 48 Hrs 0.05 | Density, gm/cc | |
| Explosion in 100 Hrs lione | Brisance, % TNT | |
| Flammability Index: | Detenstion Rate: Confinement | |
| Mygroscopicity: % 25°C, 30'S PH 0.19 | Condition Charge Diameter, in | |
| Valatility: | Density, gm/cc Rote, meters/second | |

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

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| Fregmentation Test: | Shaped Charge Effectiveness, TFT = 100: |
|-----------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, lb | Gioss Cones Stevi Cones Hole Volume Hole Depth |
| Total No. of Fragments: For TNT | Celer: Almost white |
| For Subject HE ³ _R 3 3 inch HE, M42A1 Projectile, Lat KC-5: Density, gm/cc Charge Wt, Ib | Principal Uses: Igniter powder; pyrotechnic compositions |
| Totol No. of Fregments; For TNT For Subject HE | Method of Looding: Pressed and extruded |
| | Lunding Density: gm/cc |
| Fragment Velocity: ft/sec At 9 ft At 251/2 ft | Storage: |
| Density, gm/cc | Method Dry |
| Blast (Rolative to TNT); | Hozard Class (Quantity-Distance) Class 9 |
| Air: Peak Pressure | Compatibility Group |
| Inipulse Energy | Exudation None |
| Air, Confined: Impulse | |
| Undor Water: Penik Prassure | |
| impulse Energy | |
| Underground: Peak Pressura | |
| Impulse Energy | |
| | |

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

Solubility in the following substances:

Solvent

Nitrobenzene Water Alcohol (Ethyl) Acetone Benzene Butyl acetate Carbon tetrachloride Dimethylformamide Ether (Ethyl) Acetic Acid Witric Acid Crystalling form <3 gm in 100 cc, at 23°C ~ 5 gm in 100 cc, at 210°C 0.10 gm in 100 cc, at 100°C Insoluble Insoluble Insoluble Insoluble Very soluble Insoluble Insoluble Soluble Long rectangular glistening platss from nitrobenzene

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Preparation:

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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 swirl. 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 mitric acid under agitation. The mixed acid is cooled to 10° C. 29.2 grams of tetranitro-oxanilide is clovely added to the mixed acid under rapid sgitation maintaining the temperature at 80-10°C. After the addition of the TNO 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-oxanilide (HNO) "slurry" is filtered on a Buchner funnel and purified as explained under "Tetranitro-oxanilide."

Origin:

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

References: 36

(a) L. Gowen and R. Dwiggens, Case Gun Ignition Studies, 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-TF1-88, 20 December 1954.

(c) S. Livingston, Preparation of Tetranitro Carbazole, PA themical Research Laboratory Report 136, 330, 11 April 1951.

(d) S. Livingston, Development of Improved Ignition Type Powders, PATR No. 2267, July 1956.

36See footnote 1, page 10.

beta-HMX (a)

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AMCP 706-177

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| Semposition: CH % | Molecular Weight: (C ₁ H ₈ N ₈ O ₈) | 296 |
|------------------------------------------------------------------|----------------------------------------------------------------------------------|-------------------|
| C 16.2 02N-N N-N02 | Oxygen Belance; CO ₂ % | -21.6 |
| H 2.7. H ₂ C CH ₂ | CO % | 0.0 |
| N 37.9 02N-N N-NO2 | Density: gm/cc Crystal | 1.90 |
| 0 43.2 CH ₂ | Melting Point: °C Capillary met Koffer Micro Het Sta | hod 273 ge 280 |
| C/H Ratio 0.095 | Freezing Point: "C | ······ |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 32 | Boiling Point: *C | |
| Sample Wt 20 mg | Refractive Index, na | |
| Picatinny Arsenal Apparatus, in. 9 Sample Wt, mg 23 | n _a , | |
| Sample Withing 23 | n.20 | |
| Friction Pendulum Test: | Vacuum Stability Test: | <u></u> |
| Steel Shoe Explodes | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | |
| Rifle Bullet Impact Test: Trials | | 0.37 |
| % | 120°C | 0.45 |
| 70 Explosions | 135°C | |
| Partials | 150°C | 0.62 |
| Burned | 200 Grem Bomb Sand Test: | |
| Unoffected | Sand, gm | 60.4 |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) 380 | Minimum Detonating Charge, gm | |
| 1 | Mercury Fulminate | |
| 5 <u>327</u> 10 <u>306</u> | | 0.30 |
| | Tetryl | |
| 20 | Ballistic Mortar, % TNT: | 150 |
| | Trauzi Test, % TNT: | 145 |
| 75°C Internetional Heat Tasi: % Loss in 48 Hrs | Plate Dant Test: Method | |
| 100°C Heet Test: | Condition | |
| % Loss, 1st 48 Hrs 0.05 | Confined | |
| % Loss, 2nd 48 Hrs 0.03 | Density, gm/cc | |
| Explosion in 100 Hrs None | Brisance, % TNT | |
| Flammability Index: | Datometion Rate: Confinement | |
| Hygroscopicity: % | Condition | |
| 30°C, 95% RH (c) 0.00 | Charge Diameter, in. Density, gm/cc | 1.84 |
| | | |

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beta-HMX

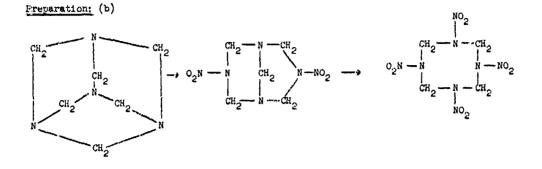
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| Booster Sensitivity Test: Condition | | | Decomposition Equation: Oxygen, atoms/sec | (e) 10 ^{19.7} |
|-------------------------------------------|------------|----------------|---------------------------------------------------------|---------------------------|
| Tetryi, gm | | | (Z/sec) | 10 |
| Wax, in. far 50% Deta | vation | | Heat, kilocalorie/mole | 52.7 |
| Wax, gm | | | (SH, kcal/mol) Temperature Ronge, *C | 271-314 |
| Density, gm/cc | | | Phase - | Liquid |
| | | | | |
| Heat of: Combustion, cal/gm | | 2362 | Armer Plata Impact Test: | |
| Explosion, col/am | (e) | 1356 | | |
| Gas Volume, cc/gm | ., | | 60 mm Martar Projectile: 50% Inert, Velocity, it/sac | |
| Formation, cul/gm | (e) | -60.5 | Aluminum Fineness | |
| Fusion, col/gm | | | | |
| | | | 500-là General Purpore Bombi | N1 |
| Specific Heat: col/gm/*C | | stallized (g) | | |
| <u>^</u> | °c | | Plote Thickness, inches | |
| -75 0.153 | 85 | 0.283 | | |
| 0 0.228 | 90 | 0.290 | 1 | |
| 25 0.248 50 0.266 | 100 | 0.295 | 11/4 | |
| 50 0.266 75 0.282 | 125 150 | 0.307 0.315 | 11/2 | |
| 17 01206 | ~,~ | ر عل ٥٠ | - 13. | |
| Burning Rate: | | | | |
| cm/sec * | | | Bomb Drop Test: | |
| Thermal Conductivity: cal/sec/cm/*C | | | T7, 2000-16 Semi-Armor-Piero | ilag Bomb vs Concrete: |
| | ····· | | Max Sofe Drop, ft | |
| Coefficient of Expension: Linear, %/*C | | | | • |
| | | | 300-16 Ganerel Purpost Remi | s vs. Concrete: |
| Volume, %/*C | | | Height, ft | |
| Hardness, Mohs' Scale: | (e) | 2,3 | Trials | |
| murunus, mons' 30616; | («) | 213 | Unaffected | |
| Young's Modulus: | <u></u> | | Low Order | |
| E', dynes/cm? | | · | High Order | |
| | | | | |
| E, Ib/inch ² | | | 1000-ib Ganeral Purpose Som | b vs Concrete: |
| Density, gm/cc | | | 11.2.3.4.4 | |
| Compressive Strength: Ib/ | /inch? | | | |
| wempressive arrength: 10/ | men. | | Trials | |
| | | | Urioffected | |
| Vapar Prossure: | | | Low Order | |
| *C mr | n Mercury | | High Order | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

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Two men are required to regulate the addition of reagents and control the temperature during the initial stage addition; one man 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 trup). The flask is placed in a pan with steam and cold water inlets, for temperature control.

Five no of acetic anhydride and 250 we glacial acetic acid are poured into the flask and the temparature 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 hexamins in 55 gm of glacial acetic acid, 100 ec of acetic anhydride und 40 cc of a solution of 32.3/57.7-ammonium nitrate/98% nitric acid) are then added simultaneously, continuously and equivalently over a 25-minute perici. The reaction mixture is aged 15 minutes.

The second stage reagents (60 co of 42.3/57.7, ammonium nitrate/98% nitric acid and 150 co 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 steam bath for 12 hours. Cool, filter and dry the RDX-HMX precipitate (yield 73% HMX).

The RDX is destroyed, leaving HMX, as follows: 1025 gm of the crude product are placed in a solution of 15 gm sodium tetraborate decalydrate in 5 liters of water, heated to boiling with sgitation, and 5 N NaOH 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 RDX. Filter the HMX from the hot mixture; yield 612 gm, mp 279.5°-280.5°C. Recrystallization from nitromethane yields material melting at $281^{\circ}-282^{\circ}C$.

Origin:

Was discovered as an impurity (by-product) in the mitration of hexamethylone-tetramine to form RDX. It is now manufactured directly by the process described above and has valuable use in explosive systems.

Removal of RDX from HAX-RDX Mixtures and Recovery of a RDX-HMX Mixture (This procedure appears suitable for use with mixtures containing 80% or more HMX):

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beta-HMX

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Procedure:

500 grams of HMX 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-HMX-acetone solution is decanted.

To the residual HMX-RDX, another 500 cc of acetone is added. The slurry is heated on the steambath and while boiling, agitated for several minutes. The boiling RDX-HMX-acetone solution is decanted. The residual HMX is now washed with cold acetone into a funnel. This HMX is now taken up in 95% alcohol, filtered and dried. Yield 35,.9 gm or 70.78%.

All the acetone extracts are combined and evaporated to dryness. Yield 137.5 gm or 26.5%.

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 | 0.128% 2.24% |
| Total | 100.00% |

Various samples were analyzed for RXD content:

| 1. Crude HMX | 12.25% RDX |
|---------------------------------|------------|
| 2. After first acetone washing | 6.0% RDX |
| 3. After second acetone washing | 2.0% RDX |
| 4. After third acetone washing | 0.0% RDX |
| RDX-HMX sample recovered | 54.5% RDX |

Preparation of Fine Particle-size HMX by the Aspirator Method:

- 1. Dissolve 1100 gm HMX in 4400 cc of dimethyl sulfoxide.
- 2. Filter the HIX solution.
- 3. Connect a clean aspirator to the water line.
- 4. Place a 55 gallon clean drum under the aspirator.
- 5. Fasten a polyethylene tubing, long enough to reach easily to the bottom of the HMX-
- dimethyl sulfoxide container, to the side inteke of the aspirator.
- 6. 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 HMX container.
 White milky fine HMX separates out in the drum. Total duration of run is approximately 7 minutes.
- 9. After all the HAX solution is sucked out of the container, the water is turned off.
- 10. The material is filtered and water washed.
- 11. If any HMX is required, the material can be alcohol and ether washed.

A more efficient method to recover the RDX-HMX mixture;

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

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beta-HMX

Color:

White

Storage:

| Exudation | None |
|----------------------------------|--------------------------------|
| Compatibility Group | Group L (dry) Group M (wet) |
| Hazard Class (Quantity-Distance) | Class 9 |
| Method | Dry |

References: 37

(a) O. E. Sheffield, E. J. Murray, A. L. Rosen and B. W. Kanouse, <u>Properties of HMX</u>, PA Chemical Research Laboratory Report No. 52-IM1-23, 7 April 1952.

(b) W. E. Bachmann, The Preparation of HMX, OSRD Report No. 1981, 3 November 1943.

(c) S. Livingston, Characteristics of Explosives HMX and DPEHN, PATR No. 1561, 6 September 1.945.

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

(e) O. H. Johnson, HMX as a Military Explosive, NAV(RD Report No. 4371, 1 October 1956.

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

| 1 | 3 | <u>6</u> | I | 2 |
|------|------|----------|------|--------------|
| 1741 | 2183 | 2016 | 1737 | 1709 2059 |

(g) C. Lenchitz, W. Beach and R. Valicky, <u>Enthalpy Changes, Heat of Fusion Pnd Specific</u> <u>Heat of Basic Explosives</u>, PATR No. 2504, January 1955.

³⁷See footnote 1, page 10.

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| Composition: | | Molecular Weight: | 91 |
|---------------------------------------------------------------|----------------|---------------------------------------|------------|
| H-X | 49 | Oxygen Belance: | E) |
| me | 29 | ົງ.% ວ.% | -51 -27 |
| | 22 | Density: gm/cc Cast | 1.90 |
| Aluminum | 22 | Melting Point: *C | |
| C 11 D | | | |
| C/H Ratio | | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | | Boiling Point: "C | |
| Sample Wt 20 mg | 17 | Refractive Is dex, no | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 17 25 | na | |
| winkie wry nig | e) | n | |
| Friction Pendulum Test: | | Vacuum Stability Test: | |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | * |
| with the line is a weak to the second | | - 100°C | |
| Rifle Bullet Impact Test: 10 Trials , 3/16"_Steel | י א 1/8" Al | 120°C | 0.37 |
| Explosions 90 | 50 | 135°C | |
| Fartials | | 150°C | |
| Burned 10 | | | |
| Unaffected 0 | 50 | 200 Gram Bomb Send Test: Sand, arn | 61.3 |
| | • | Sana, gri | 01.3 |
| Explusion Temperature: | °c | Sensitivity to Initiation: | |
| Se onds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | *** | Mercury Fulminote | |
| 5 Flames erratical | Ly 370 | Leod Azide | 0.30 |
| 10 | | Tetryi | |
| 15 | | Bellistic Morter, % TNT. | 120 |
| 20 | | Trouzi Test, % TNT: | |
| 75°C International Heat Test: | ········· | | |
| % Loss in 48 Hrs | | Plote Dent Test; Method | |
| 100°C Heet Test: | | Condition | |
| % Loss, 1st 48 Hrs | | Confined | |
| % Loss, 2nd 48 Hrs | | Density, gm/cc | |
| Explosion in 100 Hrs | | Brisance, % TNT | |
| | | Detonation Rate: | |
| Flemmebility Index: | | Confinement | None |
| Hygroscopicity: % | | Condition | Cast |
| | | Charge Diameter, in, 1. | |
| Ne - 1 - 111 | | Density, gm/cc | 1,90 |
| Velatility: | | Rate, meters/second | 7866 |

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| Booster Sensitivity Test: | | Decomposition Equation: |
|--------------------------------------------|----------------------|---------------------------------------------------|
| Condition | | Oxygen, atoms/sec (Z/sec) |
| Tetryl, gm | | Heat, kilosalorie/mole |
| Wax, in. for 50% Detonation | | (ΔH , kcal/mol) |
| Wax, gm | | Temperature Range, *C |
| Density, gm/cc | | Phase |
| | · | |
| Heat of: | <i>*</i> * | Armor Plate Impact Test: |
| Combustion, cal/gm | 3687 | |
| Explosion, cal/gm | 1190 | 60 mm Mortar Projectilo: |
| Gas Volume, cc/gm | 680 | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | | Aluminum Fineness |
| Fusion, col/gm | | |
| · | | 500-ib General Purpose Bambs: |
| Specific Heat: cal/gm/*C | | |
| 32 ⁵ to 74°C | 0.245 | Plate Thickness, inches |
| | | |
| | | 1 1 |
| | | 14 |
| | | 10.2 |
| | ··· | 1a* |
| Burning Rate: | | |
| cm/sec | | Bemb Drep Test: |
| | | |
| Thermal Conductivity: | | T7, 2000-16 Semi-Armer-Piercing Semb vs Concrete: |
| col/sec/cm/*C | | |
| | | - Max Sali Drop, ft |
| Coefficient of Expansion: Linear, %/*C | | |
| Linear, 707 C | | 500-ib Ganaral Purposn Bamb vs Concrete: |
| Valume, %/*C | | |
| | | Height, ft |
| Hardness, Mohs' Scale: | | Trials |
| | | Unoffected |
| Young's Modulus: | | Low Order |
| E', dynes/cm ² | | High Order |
| | | |
| E, lb/inch ² | | 1000-ib General Purpose Bomb vs Concrete: |
| Density, gin/cc | | |
| | 2260 | - Height, ft |
| Compressive Strength: Ib/inch ² | See telow | Trials |
| | | Unaffected |
| Veper Pressure: | | Low Order |
| *C mm Mercury | | High Ord: r |
| Compressive Strength: 15/inch | # | |
| Average (10 tests) | 2260 | Ultimate Teformation: 5 |
| High Low | 25 30 1910 | Average (10 tests) 2.91 |
| | L 710 | H1. h 3.22 Low 2.52 |
| | | 1 LV# 4+74 1 |

* Test specimen 1/2" x 1/2" cylinder (approximately 3 gm) pressed at 3 tons (4,000 1b) total load or 30,000 psi with a 2 minute time of dwell.

**

| regmentation Test: | Shaped Charge Effectiveness, TNT = 100 | • | |
|----------------------------------------|----------------------------------------------------------------------------------------------------------------------------|---------------|--|
| 90 mm HE, M71 Projectile, Lot WC-91: | Glass Cones Steel Cor | 145 | |
| Density, gm/cc | Hole Volume | | |
| Charge Wt, Ib | Hole Depth | | |
| Total No. of Fragments; | Color: | Gray | |
| For TNT | | 0103 | |
| For Subject HE | Principel Uses; HE projectile and 1 | bomb filler | |
| 3 inch HE, M42A1 Projectile, Let KC-5: | | | |
| Density, gn./cc | | | |
| Charge Wt, Ib | | | |
| Total No. of Fragments; | Method of Locding: | Cast | |
| For TNT | matina at realing: | 48 5 | |
| For Subject HE | | | |
| regment Velocity: ft/sec | Looding Density: gm/cc | 1.90 | |
| At 9 ft | | | |
| At 251/2 ft | Storage: | | |
| Density, gm/cc | Method | Dry | |
| last (Relutive to TNT): | Hazard Class (Quantity-Distance) | Class 9 | |
| Air: | Compatibility Group | Group I | |
| Peak Pressure . | | 01000 | |
| impulse | Exudation | None | |
| Energy | | | |
| Air, Confined: | Work to Produce Rupture: ft-lb/inch3 * | | |
| Impulse | Average (10 tests) | 2.77 | |
| Under Water: | High | 3.39 | |
| Dider Weter: Peak Pressure | Low | 2.40 | |
| Impulse | Efflux Viscosity, Saybolt Second | <u>:</u> 24.8 | |
| Energy | | | |
| Undarground: Peak Pressure | | | |
| impulse | 1 | | |
| Energy | | | |
| | *Test specimen 1/2" x 1/2" cylind mately 3 gm) pressed at 3 tons (total load or 30,000 psi with a time of dwell. | (5.000 it) | |

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Modulus of Elasticity: *

| <u></u> | | lb/inch ² | • |
|---------|---|----------------------|---|
| Average | | 89,200 | |
| High | : | 97,400 | |
| Low | | 76,300 | |

* Test specimen 1/1" 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 Levelopment Section, to Chief, Explosives Research Section, Picatinny Arsenal, dated 12 May 1958. Subject: "Properties of Octols and HTA-3."

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

³⁸See footnote 1, page 10.

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HTA-3

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Lead Azide

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| Composition: % | Moleculer Weight: (PbN ₆) 291 |
|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| N 26.8 N=N-N-Po-N-N=N | Oxygen Balancu; CO.º % -5.5 CO % -5.5 |
| РЬ 71.2 | Density: gm/cc Crystel 4.80 Descrinated 4.38 |
| | Multing Point: *C Decomposes |
| C/H Ratio | Freezing Point: *C |
| Impact Sensitivity, 2 Kg Wt: Pure Dextrinated Bureau of Mines Apparatus, cm 10 1? | Boiling Point: "C |
| Somple Wt 20 mg Picatinny Arsenol Apparatus, in. 3 5 | Refrective Index, no |
| Picatinny Arsenol Apparatus, in. 3 5 Sample Wt, mg 30 28 | nıs |
| | n ^b |
| Friction Pendulum Test: | Vocuum Stability Test: Dextrinated |
| Steel Shoe Explodes Fibe, Shoe Explodes | cc/40 Hrs, at 90°C |
| LINE TURE TURE TENTON | 100°C 1.0 |
| Rifle Sullet Impact Test: Triuls | 120°C 0.07 |
| % ' | 135°C |
| Explosions Partials | 150°C |
| Burned | 200 Gram Bomb Send Test: |
| Unaffected | |
| | Sond on Black powder fuse 19.0 |
| Explosion Temperature: 'C Seconds, 0.1 (no cap used) 396 | Sensitivity to Initiation: Minimum Detonating Charge, gm |
| 1 356 | Mercury Fulminate |
| 5 Explodes 340 | Lead Azide |
| 10 335 | Tetryl |
| 15 335 | |
| 20 335 | Belistic Morter, % TNT: |
| 75°C International Heat Test: | Treuxi Test, % TNT: (a) 39 |
| % Loss in 48 Hrs | Plate Dent Test: Method |
| 100°C Heat Test: | Condition |
| % Loss, 1st 48 Hrs 0.34 | Confined |
| % Loss, 2nd 48 Hrs 0.05 | Density, gm/cc |
| Explosion in 100 Hrs Ilone | Brisonce, % TNT |
| Flammability Index: | Detenution Rote: Pure Lead Azide Confinement |
| Hygrescepicity: % Dextrinated Not Dextrinated 30°C, 30% [3] 0.0 0.03 | Condition Pressed Charge Diameter, In. |
| Valatility: | Density, gm/cc 2.0 3.0 4.0 |
| | Rate, meters/second 4070 4630 5180 |

| ; | Load Azide | AMCP 706-177 |
|-------------------------------------------------|------------------------------------------------------|-------------------------------------------|
| Fragmentation Test: | Shaped Charge Effectiveness, T | NT = 100: |
| 90 mm HE, M71 Projectile, Lat WC-91: | Glass Cones | Steel Cones |
| Density, gm/cc | Hole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total No. of Fragments; | Coler: | White-buff |
| For TNT | | WILLCE-CUIT |
| For Subject HE | Principal Uses: Detonators, | priming compositions. |
| 3 inch HE, M42A1 Projectile, Lot KC-5: | | ial blasting caps |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fragments; | Method of Loading: | Pressed |
| For TNT | | riebacu |
| For Subject HE | | · · · · · · · · · · · · · · · · · · · |
| | Looding Fensity: gm/cc ps 3 5 10 | i x 10 ³ 15 |
| agment Velocity: ft/sec At 9 ft | 2.62 2.71 2.96 | 3.07 |
| At 251/2 ft | Storage: | |
| Density, gm/cc | Method | Wet |
| last (Relative to TMT); | Hozard Class (Quantity-Disto | ance) Class 9 |
| Air: | · Compatibility Group | Group M (wet) |
| Peak Pressure | | |
| Impulse | Exudation | lione |
| Energy | | |
| Air Confined. | Compatibility with Metal | <u>a:</u> |
| Air, Confined: Impulse | Dry lead azide does no rode steel, iron, nickel | t react with or cor- |
| Under Weiter: | zine, copper, tin or rad | mium. I' does not |
| Peak Pressure | affect coatings of acid- oil, NRC compound or she | proof tlack raint, |
| impulse | the presence of moisture | corrodes zinc and |
| Energy | copper; and with copper, l; sensitive and dangero | it forms the extreme- us copper szide. |
| Underground: | <u>Cpecific Heat: cal/gm/°C</u> | |
| Peak Pressure Impulse | °c . | |
| Energy | -50 U | 0.110 0.110 |
| Heat of: | 25 | 0.110 |
| | 50 | 0.110 |
| Explosion, cal/sm 367 | Thermal Conductivity: | |
| Cas Volume, cc/gm 308 Formation, cal/gm -346 | sal/sec/cm/°C (Pure) | 1.55 x 10 ⁻⁴ |
| Formation, 281/Em - 340 | all beer ciur o (filler | 1777 × 10 |

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Lead Azide

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Compatibility with Metals:

<u>Dry:</u> Steel, iron, nickel, aluminum, lead, zinc, copper, tin, stainless steel, brass and bronze were unaffected by six years' contact with dry lead azide at ambient temperature and 50°C. Monel, chrome-nickel and Incomel were unaffected under the same conditions in two and one-half years.

<u>Wet:</u> Copper and zinc are rapidly attacked by moist lead azide, while aluminum is not attacked in 24 hours. Monel, chrome-nickel and Inconel a.e not attacked by lead azide $(\frac{1}{2})$ moisture) after 29 months' exposure at ambient temperature and 50°C, and J-1 magnesium-aluminum alloy is very slightly corroded.

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Lead Azite

| Sample Tested | Lead Azide Dry | p | Azide lus Water | Lead A plu 20% Wa | 8 | plus 20% Ethyl Alco hol (95%) |
|---------------------------------------------------------|-------------------|--------------------|------------------------------|-------------------------|------------------|-------------------------------------|
| Friction Pendulum Te | | ن <u>الم</u> | | | | |
| (All IA dextrinated) | 1 | | | | | |
| Shoe | Fiber | Fiber | Steel | Fiber | Steel | Fiber |
| No. of Trials Explosions Cracklings Unaffected | 1 1 0 | 10 0 0 10 | 10 12 12 | 10 0 0 10 | 4 1 2 1 | 1 1 0 0 |
| Impact Sensitivity, | 2 Kg Wt: | | | | | |
| (All LA dextrinated) | | | | | | |
| PA Apparatus, inc | ihes 4 | 9 | | | 9 | μ |
| Activation Energy: (| (c) | | | | | |
| Kcal/mole Induction Period, | seconds | 23.74 0.5-10 | | | • | |
| Initiating Efficience | y, Grams Requ | ired to Gi | ve Comple | te Initiat | ions of: | |
| | | Dextrinat | ed Azide | (gm) | | |
| TNT Tetryl RDX PETN | | | 0.25 0.10 0.05 0.02 | | | |
| Sensitivity to Stati | c Discharge, | Joules (Pu | re Lead A | zide) (b) | • | 0,0070 |

Lead Azide

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

| Sample Wt (gm) | Laterial | <u>ee</u> |
|----------------|--------------------------------|-----------|
| 1.0 | Lead Azide | 0.50 |
| 1.0 | Black Powder | 6.38 |
| 2.0 | 50/50, Lead Azide/Black Powder | 1.26 |

Solubility of Pure Lead Azide; gm/100 gm of Water:

| °c | ž |
|----|------|
| 20 | 0.05 |

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

2 Na - N = N = N + Pb $(NO_3)_2 \rightarrow Pb(N_3)_2 + 2 NaNO_3$

<u>Lead nitrate solution:</u> This is prepared by dissolving 164 lbs lead nitrate and 8.25 lbs 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 azide is precipitated at a solution temperature of $160^{\circ}F$, using 60 parts lead nitrate and 50 parts sodium azide 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 temperature in 12 minutes, and allowed to settle 10 minutes. The mother liquor is decented and the remaining slurry washed before packing.

/ Origin:

First prepared in 1891 by T. Curtius (Ber 24, 3345-6) by adding lead acctate to a solution of sodium or announum 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 commercial manufacture started in Europe before World War II and if the United States since 1931 as military or commercial grade "dextrinated" lead azide.

Destruction by Chemical Decomposition:

Lead azide 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 supernatant solution of sodium azide and drain into the soil.

(2) dissolving in a 10% solution of ammonium acctate 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 27% sodium nitrite, stirring, and then adding 14 times its weight of 36% nitric or glacial weetic acid. A red color produced by the addition of ferric chloride solution indicates Lead Azide is still present.

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Lead Azide

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(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. Naoum, <u>Z ges Schiess Sprengstoffw</u>, 181, 229, 267 (27 June 1932).

(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) C. Lenchitz, Ice Calorimeter Determination of Enthalpy and Specific Heat of Eleven Organometallic Compounds, PATR #2224, November 1955.

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

| <u>0</u> | 1 | 2 | 3 | 4 | 5 | <u>6</u> | I | 8 | 2 |
|----------------------------------|----------------------------|---------------------------------------------------|--------------------------------------------|------------------------------------------|----------------------------|-------------------------------------------|------------------------------------------|-----------------------------------------------------------------|------------------------------------------------|
| 550 580 600 760 1450 | 561 861 1451 1651 | 832 852 932 1132 1152 1352 1372 | 393 1393 1493 2093 2133 | 534 784 824 941 2164 2204 | 255 525 1325 1485 | 326 856 866 1316 1486 1556 | 567 637 657 707 1737 2227 | 628 708 748 788 838 1388 1528 1838 2198 | 609 719 749 769 849 999 2179 |

³⁹See footnote 1, page 10.

Lead 2,4-Dinitroresorcinate (LDNR)

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| Composition: | Molecular Weight: (PbC6H2N2O6) 405 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| $ \begin{array}{cccc} c & 17.8 \\ H & 0.5 \\ N & 6.9 \\ \end{array} $ | Oxygen Balance: CO ₂ % -32 CO % - 8 |
| 0 23.7 70 51.1 | Density: gm/cc Crystal 3.2 |
| | Melting Point: *C |
| C/H Ratio 0.549 | Freezing Point: *C |
| Impact Sensitivity, 2 Kg Wt: Bureou of Mines Apparatus, cm 1 kg vt 30 | Boiling Point: *C |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg 20 | Refrective Index, no no no no |
| Friction Pandulum Test: Steel Shoe Fiber Shoe | Vecuum Stebility Test: cc/40 Hrs, at 90°C 100°C |
| Rifle Bullet Impact Test: Trials % Explosions Partials | 120°C (73 minutes) Explodes 135°C 150°C |
| Burned Unaffected | 200 Gram Bomb Send Test: Sond jam Black powder fuse 20 |
| Explosion Temparature: 'C Seconds, 0.1 (no cap used) 1 5 Explodes 265 10 15 20 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Leao Azide Tetryl Bellistic Mortur, % TNT: |
| | Trauzi Test, % TNT: |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dent Test: Method |
| 100°C Heat Test: 0.20 % Loss, 1st 48 Hrs 0.20 % Loss, 2nd 48 Hrs 0.02 Explosion in 100 Hrs None | Condition Convined Density, gm/cc Brisance, % TNT |
| Flammability Index: | Detonation Rote: Confinement |
| Hygmscopicity: % 30°C, 90% RH 0.73 | Condition Charge Diameter, in. |
| Volatility: | Density, gm/cc Rate, meters/second |

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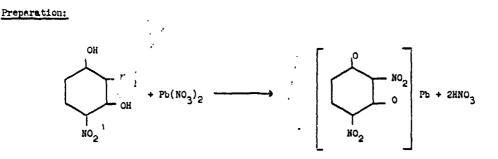
Lead 2,4-Dinitroresorcinate (LDNR)

| Fregmentation Test: Sheped Charge Effectiveness, TNT == 100: | | |
|--------------------------------------------------------------|--------------------------|------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: | Glass Cone | s Steel Cones |
| Density, gm/cc | Hole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total No. of Fragments; | Color: | Red or yellow |
| For TNT | | |
| For Subject HE | Principal Uses: | Electric detonators |
| 3 inch HE, M42A1 Projectile, Let KC-5: | | |
| Density, gm/cc | | |
| Cixinge Wt, Ib | | |
| Total No. of Fregments: | Niethad of Loading: | Fressed |
| For TNT | | 1148654 |
| For Subject HE | Leeding Density: gm/cc | |
| Re | | |
| Fregment Velocity: ft/sec At 9 ft At 251/2 ft | Storage: | |
| Density, gm/cc | | |
| | Method | Wet |
| Blast (Relative to TNT): | Hazard Class (Quantity-[| Distance) Class 9 |
| Air: | Compatibility Group | |
| Peak Pressure | | |
| impulse | Exudation | None |
| Energy | | |
| Air, Confined: | | : 0.4 gm LDNR does not |
| Impulse | initiate tetryl pre | ssed at 3000 pai. |
| Under Weter: | Heat of: | |
| Peak Pressure | Explosion, cal/gm | 270 |
| Impulse | | |
| Energy | | |
| Underground: Peak Pressure | | |
| Impulse | | |
| Energy | | |
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Lead 2,4-Dinitroresorcinate (LDNR)

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To a solution of 5 grams of purified dinitroresorcin and 2.65 grams of anhydrous sodium carbonate in 500 cc of boiling water is added slowly a solution of 10 grams of lead nitrate dissolved in 60 cc of boiling water. The reaction mixture is constantly stirred during the addition 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 and ether. It is dried in a steam oven.

Origin:

2,4-dinitroresorcin was described in the 1881 edition of Beilstein (Beil VII, 885). The same compound was described in more detail by Weselsky, Benedikt and Hubl in 1882 (M II, 323). The lead salt of 2,4-dinitroresorcinol appears to have been prepared between World War I and World War II by treating resorcinol with nitrous acid and oxidizing the resulting dinitrosoresorcinol to dinitroresorcinol. Lead nitrate solution was then added to a solution of the 2,4-dinitroresorcinol to which sodium carbonate had been added to form the soluble sodium salt (J. D. Hopper, PATR No. 480, March 1934). The LDNR 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).

References: 40

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

| <u>o</u> | <u>3</u> . | <u>4</u> | 8 | 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)

| AMCP 706-177 Lead 4,6-Dinitrores | sorcinol Basic (LDNR Basic) | (|
|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|------|
| Composition: | Molecular Weight: (Pb2C6H4N208) 646 | ···· |
| $^{\%}$ 0 - Pb - OH C 11.2 H 0.6 02N + OH N 4.3 02N + OH | Oxygen Balence: CO ₂ % -20 CO % - 5 | |
| о 19.8 Рь 64.1 0 — Рь — ОН | Density: gm/cc | |
| NO. | Melting Point: *C 213 | |
| NO ₂ C/H Ratio 0.177 | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 1 kg wt 60 | Boiling Point: "C | |
| Bureau of Mines Apparatus, cm 1 kg vrc 60 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg 20 | Refractive Index, nº nº nº | |
| Friction Pendulum Test: Steel Shoe Fibe- Shoe | Vocuum Stability Test: cc/40 Hrs, at 90°C | |
| Rifie Builet Impact Tust: Trials % Explosions Partials | 100°C 120°C 135°C 150°C | |
| Burned Uvalfected | 200 Grem Bumb Send Test: Saleck Bowder fuse 15 | (- |
| Explosion Temperature: "C Seconds, 0.1 (no cap used) 1 5 Explodes 295 10 | Sensitivity to Initiation: Minimum Datonating Charge, gm Marcury Fulminate Lead Azide Tetryl | |
| 15 20 | Ballistic Morter, % TNT: | |
| | Treuxi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 43 Hrs | Plete Dent Test: Method | |
| 100°C Heat Test: | Condition | |
| % Loss, 1st 48 Hrs 0.4 | Confined Density, gm/cc | |
| % Loss, 2nd 48 Hrs 0.0 Explosion in 100 Hrs None | Brisance, % TNT | |
| | Detonation Rate: | |
| Flammability Index: | Confinement Condition | ł |
| Hygroscopiaity: % | Charge Diameter, in. | |
| Veletility: | Density, gm/cc Rote, meters/second | |

| ragmentation Teet; | Shaped Charge Effectives | ness, TNT == 100: |
|----------------------------------------|---------------------------|------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: | Glass Ca | ones Steel Cones |
| Density, gm/cc | Hole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total No. of Fregments: | Calor: | Red or yellow |
| For TNT | | Ned of yellow |
| For Subject HE | Principal Uses; | Electric detonators |
| 3 inch HE, M42A1 Projectile, Lot KC-5: | | |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fragments: | Method of Londing: | Pressed |
| For TNT | | 5 2 4 00 64 |
| For Subject HE | Loeding Density: gm/cc | |
| ragment Velecity: ft/sec | | |
| At 9 ft | | |
| At 251/2 ft | Storege: | • |
| Density, gm/cc | Method | Wet |
| last (Relative to TNT): | Hazard Class (Quantit | y-Distance) Class 9 |
| Air: | Compatibility Group | |
| Peak Pressure | | |
| Impulse | Exudation | None |
| Energy | | |
| Air, Confined: | | ey: 0.4 gm LINR Basic |
| Impulse | does not initiate psi. | tetryl pressed at 3000 |
| Under Weter: Peak Pressure | | |
| Impulse | | |
| Energy | | |
| Underground: | | |
| Peak Pressure | | |
| Impulse | · · | |
| Energy | | |
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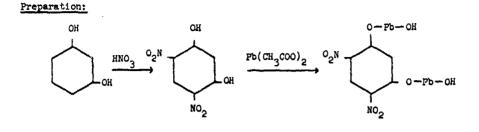
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Lead 4,6-Dinitroresorcinol Basic (LDNR Basic)

AMCP 706-177



Lead 4,6-Dinitroresorcinol Basic (LINR 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 a mortar to pass a U. S. Standard No. 6 mesh screen. Four hundred grams of 98 percent mitric acid in a one pint capacity Dewar 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 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 five 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 43.6 grams. The crude 4,6-INR is purified by first dissolving the product in an aqueous 5 percent sodium hydroxide solution (17.4 grams of sodium hydroxide in 340 cc of water). The resulting solution is then neutralized by gradually adding it to a boiling solution of 21.4 grams of 98 percent sulphuric acid in 150 cc of water. The resulting precipitate of 4,6-INR 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 accetate 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) showe, is dispersed in 270 cc of water by vigorously beating with a motor stirrer. After heating this disper 1 to 90° 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° C. The basic lead 4,6-DNR is washed once by decentation, and again on the filter with alcohol. After drying overnight in a desiccator charged with calcium chlorids, the product weighs 15.6 grams.

Origin:

Both the 2,4- and 4,6-dinitroresorcin were described 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 more 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-154-21a, "Manufacture of 4,6-Dinitroresorcin and Lead 4,6-Dinitroresorcinats"). 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-reu form. Both products have the same chemical composition and the same sensitivity to impact (PATR 1448, September 1944).

Lead Styphnate

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| Composition: | Molecular Weight: (PbC6H3N309 |) 468 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|----------|
| $\begin{array}{c cccc} & & & & & & & \\ C & & 15.4 & & & & \\ H & & 0.6 & & & \\ N & & 9.0 & & & \\ \end{array} \begin{array}{c} & & & & & \\ 0_{2}N & & & & \\ \end{array} \begin{array}{c} & & & & \\ & & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \begin{array}{c} & & & \\ & & & \\ \end{array} \end{array}{c} \end{array}{c} \end{array}{c} \end{array}{c} \end{array}{c} \end{array}{c} \end{array}{c} \end{array}{$ | Oxygen Belence; CO₂ % CO % | -19 2 |
| 0 30.8 Pb 44.2 | Density: gm/cc Crystal | 3.02 |
| NO ₂ | Melting Point: "C Explodes | 260-310 |
| C/H Rotio 0.320 2 | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 17 | Boiling Feint: "C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 3; (8 oz wt) 8 Sample Wt, mg 22 | Refrective Index, n ₂₀ n ₂₀ n ₂₀ | |
| Friction Pendulum Test: | Vecuum Stability Test: | |
| Steel Shoe Detonates | cc/40 Hrs, at | |
| Fiber Shoe Detonates | 90°C 100°C | 0.4 |
| Rifie Bullet Impact Test: Trials | 120°C | 0.3 |
| % | 135*C | |
| Explosions De state | 150°C | |
| Portials Burned | | |
| Unaffected | 200 Grem Bomb Send Test: Sand. am | 24 |
| | Sond, gm Black poyder fuse | <u> </u> |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) | Sensitivity to Initiation: | |
| Seconds, O.I. (no cup used) | Minimum Detonating Charge, g Mercury Fulminate | Trace# |
| Explodes 282 | Lead Axide | Trace# |
| 10 276 | * <.001 gm, alternative | |
| 15 272 | | |
| 20 267 | Ballistic Mortur, % TNT: | |
| 75°C International Heat Test: | Treuzi Test, % TNT: (a) | 40 |
| % Loss in 48 Hrs | Plate Dent Test: Mathod | |
| 100°C Heat Test: | Condition | |
| % Loss, İst 48 Hrs. 0.38 | Confined | |
| % Loss, 2nd 48 Hrs 0.73 | Density, gm/cc | |
| Explosion in 100 Hrs Nane | Brisance, % TNT | |
| Flammability Index: | - Detention Rate: Confinement | |
| Hygroscopicity: % 25°C, 100% RH 0.05 30°C, 90% RH 0.02 | – Condition Charge Diameter, in. | |
| Valetility: | Density, gm/cc | 2.9 |
| · | Rote, meters/second | 5200 |

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Lead Styphnate

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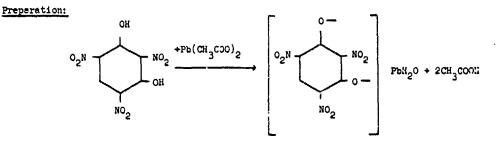
| Fragmentation Test: | Shaped Charge Effectiveness, TNT = 100 | : | |
|---------------------------------------------------------------------------------------------|-------------------------------------------------------------------|----------------------------------|--|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, Ib | Glass Cones Stee! Cor Hole Volume Hole Depth | 185 | |
| Total No. of Fragments: For TNT | Celey: Orange-reddish brow | m | |
| For Subject HE 3 Inch HE, M42A1 Projectile, Lot KC-S: Density, gm/cc Charge Wt, Ib | Principal Uses: Igniting charge, an of priming composit | | |
| Total No. of Fragments: For TNT For Subject HE | Method of Looding: | Pressed | |
| Fregment Velecity: ft/sec | Looding Density: gm/cc | | |
| At 9 ft At 25½ ft Density, gm/cc | Storege: Method | Wet | |
| Blast (Relative to TNT); | Hazard Class (Quantity-Distance) | Class 9 | |
| Air: Peak Pressure Impulse | | Group M (wet) None | |
| Energy Air, Confficient: Impulse | Activation Energy: kccl/mol | 75.39 | |
| Under Weiter: Peak Pressure Impulse | Induction Period, sec () Specific deat: cal/cm/ ^O C | (e) | |
| Energy Underground: Peak Pressure Impulse | 0 25 | 0.141 0.158 0.164 0.167 | |
| Energy Heat of: | ~ | 0.101 | |
| Combustion, cal/gm1251Explosion, cal/gm457Cas Volume, cc/gm368Formation, cal/gm-92 | | | |

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Lead Styphnate

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Dissolve 14.4 gm lead nitrate and 1 cc of 36% acetic woid in 320 cc distilled water. Dissolve 4 gm 2,4,6-trinitroresorcinol and 1.73 gm sodium carbonate in 80 cc distilled water. Add the lead acetate solution to the trinitroresorcinol solution, under sgitation, keeping the temperature at 70° - 75° C and continue stirring for 3 hours at this temperature. Cool to 20° 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: \$ | |
| 3 hours 6 hours 9 hours | | 0.02 0.23 0.23 |
| | for 2 Months at 80°C, on: | |
| Explosion Temp Sand Test Valu Sensitivity to | | N11 N11 N11 |
| Solubility, gm/10 | 0 gm (5) in: | |
| Glycol Di | acetate | |
| °c | 2 | |
| 20-25 | 0.1 | |

Origin:

مهامه والمراهدة البراغ والروم المردية كالمرار والب

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 Sprengstoffty 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 Kasan (Russia) 2, 81-5 (1935).

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Lead Styphnate

Destruction by Chemical Decomposition:

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

References: 41

(a) Report AC-956/Org Ex 74.

(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.

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

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

| <u>0</u> | 1 | 2 | <u>3</u> | <u>r</u> | <u>6</u> | <u>7</u> | <u>8</u> | 2 |
|--------------|----|--------------|-------------|----------|----------|---------------------|----------|------|
| 1450 2220 | 11 | 1352 2032 | 453 2093 | 2164 | 1316 | 407 1737 2077 | 318 | 2179 |

⁴¹See footnote 1, page 10,

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No. 41. 44

Mannitol Hexanitrate (Nitromannite)

AMCP 706-177

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| Powerstate | | |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------------|-------------|
| Kemposition: | Molecular Weight: (C ₆ H ₈ N ₆ O ₁₈) 452 | |
| C 15.9 02NOCH | Oxygen Be'ance: | |
| O NORY | CO ₂ % 7.1 CO% 28.3 | |
| н 1.8 оглосн | 20.3 | |
| N 18.6 HCONO2 | Demaily: gm/cc 1.73 | |
| 0 63.8 HCONO2 | Melting Point: °C 112-113 | |
| C/H Rc io 0.133 | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: Burgey of Mines Apportus can 11 | Seiling Peint: *C Decomposes 150 | |
| Bureau of Mines Apparatus, cm 11 Sample Wt 20 mg | Refrective Index, n2 | |
| Picatinny Arsenal Apparatus, in. 4 | | |
| Sample Wt, mg 11 | n <mark>u</mark> | |
| · · · · · · · · · · · · · · · · · · · | n3e | |
| Friction Pendulum Test: | Vocuum Stability Test: | |
| Steel Shoe Detonates | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | |
| | | |
| Rifie Bullet impact Test: Trials | 120°C | |
| Suctorian 96 | 135°C | |
| Explosions | 150°C | |
| Portials | | |
| Burned | 200 Grem Bomb Sand Test: | |
| Unoffected | Sand, gm 68.5 | |
| Explosion Tempereture: 'C | Sensitivity to Initiation: | _ |
| Seconds, 0.1 (no cap used) 160-170 (a) | Minimum Detonating Charge, gm | |
| 1 2 <u>3</u> 2 (b) | Mercury Fulminate | |
| 5 175 (c) | Leoul Azide 0.06 | |
| 10 | Tetryl | |
| 15 | | |
| 20 | Bellictic Merter, % TNT: | |
| 75°C International Heat Test: | Trauxi Yest, % TNT: (c) 172 | |
| % Loss in 48 Hrs 0.4 | 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 (Frothed) 48 hours | Brisonce, % TNT | |
| | | |
| Fianmability Index: | Detensition Rete: (d) Confinement Xes | |
| | | |
| Hygroscopicky: % 30°C, 90% RH 0.17 | | 99 <i>4</i> |
| | Charge Diameter, in, 0.5 | |
| Voletility: | Density, gm/cc 1.73 | |
| · · · · · · | Rote, meters/second 8260 | I |

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Mannitol Hexanitrate (Nitromannite)

| Fragmantation Text: | Shaped Charge Effectiveness, TNT == | 109: |
|----------------------------------------|--------------------------------------------------------|-------------------------|
| 90 mm HE, / 173 Projectile, Let WC-91; | Glass Cones Stee | Cones |
| Density, gm/cc | Hole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total No. of Fragments: | Celer: | |
| For TNT | | |
| For Subject HE | Principal Uses: Secondary charge | |
| 3 inch HE, M42A1 Frojectile, Let KC-5: | (ref i), and in blasting be initiated by a fuse (re | |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fragments: | Mathed of Loading: | Fressed |
| For TNT | | |
| For Subject HE | Loading Density: gm/cc | |
| New your parts Market for the second | | |
| Fregment Valocity: 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 |
| Ain | Compatibility Group | |
| Peak Pressure | | |
| Impulse | Exudation | None |
| Energy | | |
| Air, Confined: | 65.5°C KI Test: | 1 |
| Impulse | Minutes | 6 |
| Under Water: Peak Pressure | Heat of: | (e, 1, g) |
| Impulse | Combustion, cal/gm 1515 | 1525 |
| Energy | Explosion, cal/gm 1390 14 Formation, cal/gm 337 | 54 1468 1520 345 366 |
| Underground: Peak Pressure | | |
| Impulse | | |
| Enevgy | | |
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Mannitol Hexanitrate (Nitremannite)

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Solubility:

- a. Insoluble in water.
- 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 Nethod) (k)

a. Cool to below 0°C, 50 gm of 98%-100% nitric acid placed in a 300 milliliter Erlenneyer 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 O^{CC} .

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 follows: by dilute aqueous sodium carbonate and finally with water. (The resulting crude mannitol hexanitrate gives 18.2% N as determined by the nitrometer.)

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

g. Bring the filtrate 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 rt 112° -113°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 substitute for mercury fulminate in percursion caps (<u>Comp rend</u>, 1847, 121). It is the bexanitric 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 HM and recommended in 1878 a method of preparation. Mannitol hexanitrate was thoroughly studied by Berthelot, Sarran and Vieille, Domonte, Menard, Strecker, Tichanowich (Ph. Naoum, <u>Nitroglycerin and</u> <u>Nitroglycerin Explosives</u>, Baltimore, 1928, pp. 156, 247-250), and particularly by J. H. Wigner (Ber <u>36</u>, 796 (1903)). More recent data have been reviewed by Guastalla and Racciu ("Mode: n Explosives," Industria Chimica <u>8</u>, 1093-1102 (1933)).

References:42

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

425ee footnote 1, page 10.

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

- (c) Ph. Naoum, Z ges Schiess Sprengstoffw (Munich), pp. 181, 229, 267 (27 June 1932).
- (d) H. Kast, Z angew Chem, <u>36</u>, 74 (1923).
- (e) A. Schmidt, Z ges Schiess Sprengstoffv 29, 262, (1934).

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

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P. Hoste, "Structure and Stability of Nitric 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) Serran and Vielle, Mém poudr 2, 161 (1884-1889).

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

(j) L. A. Burrows, U. S. Patent 2, 27,899 (23 September 1947).

(k) B. T. Fedoroff, <u>Handbook of Explosives and Related Items</u>, Picatinny Arsenal (unpublished).

(1) O. E. Sheffield, Literature Survey on Mannitol Hexanitrate, PA Chemical Research Leboratory Report No. 52-TML-16, 23 January 1952.

(m) Also see the following Picatinny Arsenal Technical Reports on Mannitol Hexanitrate:

| 2 | <u>4</u> | 2 | <u>6</u> |
|------|----------|----|----------|
| 1352 | 24 64 | 85 | 6 |

Mercury Fulminate

AMCP 706-177

| Camposition: % | Moleculur Weight: (HgC ₂ N ₂ O ₂) 285 |
|-------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| c 8.4 0-N=c | Oxygen Belence: CO2 % -17 |
| N 9.8 Hg | CO% -5.5 |
| 0 11.2 0 -N - C | Density: gm/cc Crystel 4.43 |
| Нд 70.6 | Meking Point: *C Decomposes |
| C/H Ratio | Freezing Point: "C |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 5; (1 kg Wt) 35 | Boiling Points *C |
| Sample Wt 20 mg | Refractive Index, no |
| Picatinny Arsenal Apparatus, in. 2; (1 1b vt) 4 Sample Wt, mg 30 | na |
| | ns |
| Friction Pendulum Test: | Vacuum Stability Vest: |
| Steel Shoe Explodes | cc/40 Hrs, at |
| Fiber Shoe Explodes | C.0.C |
| Rifle Bullet Impact Test: Trials | - 100°C Explodes |
| % | 120°C |
| Explosions | 135°C |
| Portials | 150°C |
| Burned | 200 Grum Bomb Sand Test: |
| Unaffected | Sond, gm Black bowder fuse 23,4 |
| Explacion Temperature: *C | Sensitivity to Initiation: |
| Seconds, 0.1 (no cap used) 263 | Minimum Detonating Charge, gm |
| 1 239 | Mercury Fulminate |
| 5 Explodes 210 | Lead Azide |
| 10 199 | Tetryi |
| 15 194 | Bailletic Mortar, % TNT: |
| 20 190 | |
| 75°C International Heat Test: | Piete Dent Test: |
| % Loss in 48 Hrs 0.18 | Method |
| 100°C Heet Test: Exploded in 16 hours | Condition |
| % Loss, 1st 48 Hrs | Confined |
| % Loss, 2nd 48 Hrs | Density, gm/cc |
| Explosion in 100 Hrs | Brisonce, % TNT |
| | Debug Debug |
| Flammability Index: | Detonation Rate: Confinement |
| · | - Condition Pressed |
| Hygroscopicity: % 30°C, 90% RH 0.02 | Charge Diameter, in. |
| | Density, gm/cc 20 3.0 4.0 |
| Veletility: | Rate, meters/second 3500 4250 5000 |

1

Mercury Fulminate

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| Fragmentation Test: | Shoped Charge Effectiveness, TNT = 100: | | |
|-----------------------------------------|---------------------------------------------------------|--------------------|--|
| 90 mm H£, A171 Projectile, Lor WC-91: | Glass Cones Steel | Cones | |
| Density, gm/cc | Hole Volume | | |
| Charge Wt, Ib | Hole Depth | | |
| Total Na of Fragments: | Color: White t | | |
| For TNT | Color: White t | o gray | |
| For Subject HE | Principel Uses: Detonators and in | gredient of | |
| 3 inch HE, M42A'l Projectile, Lot KC-5: | priming compositi | ons | |
| Density, gm/cc | | | |
| Charge Wt, 15 | | | |
| Votal No. of Fragments: | Method of Loading: psi x 10 ³ | | |
| For TNT | 3 5 10 12 | 15 20 | |
| For Subject ME | 3.00 3.20 3.60 3.70 | 3.82 4.00 | |
| Frequent Valocity: it/sec | Loading Density: gm/n; | | |
| At 9 ft | | | |
| At 25% ft | Starage: | | |
| Density, gm/cc | Method | Wet | |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) | Class 9 | |
| Air: Peak Prassure | Compatibility Group | Group M (www.) | |
| | Exudation | lone | |
| Impuise | Excapition | | |
| Energy | | | |
| Air, Confined: | Stab Sensitivity: | | |
| Impuise | Density Firing Point (inc | | |
| | <u>gm/cc 0% 50%</u> | 100% | |
| Under Water: | 3.91 3.2 4.3 4.26 1.6 2.6 | 5.5 5.5 | |
| Peak Pressure | 4.32 1.6 2.6 | 4.6 | |
| impulse | 4.50 1.6 2.5 | 4.0 | |
| Energy | Activation Energy: | j. | |
| Underground: | kcal/mol | 29.81 | |
| Peak Pressure | Induction Period, sec | 0.5-10 | |
| Impulse | Heat of: | | |
| Energy | Combustion, cal/gm Explosion, cal/gm | 938 427 | |
| | Explosion, cal/gm Gas Volume, cc/gm | 243 | |
| | Formation, cal/gm | -226 | |
| | Specific Heat: cal/gm/°C | 1.1 | |
| | Thermal Conductivity: cal/sec/cm/°C 1 | x 10 ⁻⁴ | |
| | | | |

Mercury Fulminate

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AMCP 705-177

Initiating Efficiency; Grams Required to Give Complete Initiation of:

_ . .

| | Fulluinate, |
|------------------------------|------------------------------|
| INT Tetryl RDX PEIN | 0.2) 0.20 0.19 0.17 |
| | |

Compatibility with Metals:

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

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

| Sensitivity t | o Static | Discharge, | Joules: (| Ъ) | 0.025 |
|---------------|----------|------------|-----------|----|-------|
| | | | | | |

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

| Months Storage | <u>979</u> | ecrystall <u>980</u> | 2ed Lots 981 | <u>982</u> | Uncrystal11 505.6-7/31 | |
|----------------------|-------------------------|-------------------------|-----------------|----------------|---------------------------|----------------------|
| 0 | 99.75 | 99.77 | 99.79 | 99.79 | 98.86 | 0 ⁰ m |
| 4 | 99.38 | 99+45 | 99.54 | 99.47 | 95+95 | 98.7 98.7 97.4 |
| 6 8 9 | | | | | 94.95 | 94.9 |
| 10 12 13 14 | 98.74 98.26 98.22 | 99 .56 | 97.49 | 99.06 98.79 | 90.65 | 94 .9 |
| 15 16 | 97•52 97•00 | 99.30 | 99.30 99.01 | 98.19 97.75 | 83.76 | |
| 17 18 23 26 | 95.70 94.81 | 98.66 98.58 | 98.46 | 96.69 95.90 | 79.99 74.52 63.80 | |

Chemistry:

Mercuric fulminate readily decomposes in the presence of aqueous solutions, chlorides, carjonate 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 protectively coated if used with fulminate.

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

| °C | ar. |
|----|------|
| 12 | 0.07 |
| 49 | 0.18 |

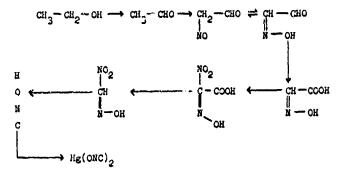
203

Mercury Fulminate

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Preparation:

(Chemistry of Powder and Emplosives, Devis)



Five gu mercury is dissolved in 25 cc of nitric acid (sp gr 1.42) without agitation, and this solution youred into 50 cc of 90% ethyl alcohol, resulting in a vigorous reaction, attended by evolution of white fumes and subsequent appearance of fulminate crystals. Red fumes then appear as precipitation of the product accelerates, and then white fumes again are evolved us the reaction moderates. After about 20 minutes the reaction is over; water is added, and the crystals are repeatedly washed, by desantation, with water to remove all acidi-'ty. The product is purified, rendered white, by solution in strong amonium hydroxide, folloved 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 poisonour cyanogen gas may be evolved.

References: 43

(a) Ph. Naoum - Z ges Schless-Sprengstoffw (Munich), pp. 181, 229, 267 (27 June 1932).

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

⁴³See footnote 1, page 10.

Mercury Fulminate

AMCP 706-177

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

| <u>o</u> | 1 | 2 | 3 | <u>4</u> | 2 | <u>6</u> | I | 8 | 2 |
|---------------------------------------------------------------|---------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------|------------------------------------------------------|-----------------------------------------------------------------|-------------------------------------------------------|---------------------------------------|---------------------------------------------------------|
| 250 480 510 550 010 680 760 1220 1450 | 301 381 561 1651 | 132 452 522 582 782 932 1192 1352 1352 1372 2032 | 23 203 393 433 833 1183 1393 2093 | 144 294 534 694 784 784 874 1104 | 65 105 255 285 365 415 425 1365 | 266 366 556 866 986 1316 1486 1556 2146 | 277 297 407 537 567 637 857 1737 | 28 78 278 318 788 1838 | 199 609 749 849 999 1079 1389 2179 |

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NM Star

| Composition: % | Meleculer Weight: (C5H9N309) | 255 | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------|--|--|
| c 23.5 02NOCH2 | Oxygen Belence: CO ₂ % CO % | - 35 - 3 | | |
| $H = 3.5 = 0_2 NO - CH_2 - C - CH_3$ N 16.6 | Density: gm/cc Liquid | 1.47 | | |
| 0 56.4 02NO-CH2 | Molting Point: *C | -3 | | |
| C/H Ratio 0.150 | Freezing Point: *C | | | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 47; (1 1b vt) 4 Sample Wt 20 mg | Boiling Point: "C Refractive Index, no | | | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg 20 | n <mark>2</mark> , | 1.4752 | | |
| Friction Pendulum Test: Steel Shoe Explodes Fiber Shoe | Vecuum Stability Tusk: 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 Sand Test: Sand, gm | 43.7 | | |
| Explesion Tempereture: *C Seconds, 0.1 (no cap used) 1 5 Ignites 235 10 15 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryl | | | |
| 20 | Ballistic Morter, % TNT: (a) | 136 | | |
| 75°C International Heat Test: | Trauzi Test, % TNT: (b) | 140 | | |
| % Loss in 48 Hrs | Plate Dent Test: Method | | | |
| 100°C Heet Test: 2.5 % Loss, 1st 48 Hrs 2.5 % Loss, 2nd 48 Hrs 1.8 Explosion in 100 Hrs Note | Condition Confined Density, gm/cc Brisance, % TNT | | | |
| Fiemmability Index: | Detenction Rate: Confinement Condition Charge Diameter, in. | | | |
| Hygroscopicity: % 30°C, 90% RH 0.07 | | | | |
| Veletility: 60°C, mg/cm ² /hr 24 | Density, gm/cc Rate, meters/second | | | |

AMCP 706-177 Metricl Trinitrate (MTN) Liquid (or Trimethylolethane Trinitrate)

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Metriol Trinitrate (MTN) Liquid

AMCP 706-177

| Fregmantation Test: | Shaped Charge Effectiveness, TN | Shapad Charge Effectiveness, TNT = 100: | | | | |
|----------------------------------------|----------------------------------------|-----------------------------------------|--|--|--|--|
| 90 mm HE, M71 Projectile, Let WC-91: | Giass Cones | Steel Cones | | | | |
| Density, gm/cc | Hole Volume | | | | | |
| Charge Wt, Ib | Hole Depth | | | | | |
| Tatal No. of Fragmants: | Celièr: 011v. | slightly turbid | | | | |
| For TNT | | erening aroun | | | | |
| For Subject HE | Principal Uses: Ingredient o | | | | | |
| 3 inch HE, M42A1 Projectile, Let KC-3: | double base | propellants | | | | |
| Density, gm/cc | | | | | | |
| Charge Wi, io | | | | | | |
| Total Na. af Fragments; | Method of Londing: | Method of Londing: | | | | |
| For TNT | | | | | | |
| For Subject HE | Leeding Density: cm/cc | Lesčing Density: cm/cc | | | | |
| Fragment Velocity: ft/sec | | | | | | |
| At 9 ft | | | | | | |
| At 25½ ft | Starage: | | | | | |
| Density, gm/cc | Method | Liquid | | | | |
| Blast (Relative to TNT); | Hazard Class (Quantity-Distan | Hazard Class (Quantity-Distance) | | | | |
| Air: Peak Pressure | Compatibility Group | | | | | |
| Impulse | Exudation | | | | | |
| Energy | | | | | | |
| Air, Confined: Impulse | Solubility in Water, gu/100 gm, at: | | | | | |
| in pase | | | | | | |
| Under Water: Peak Pressure | 25°C 60°C | <0.015 <0.015 | | | | |
| Impulse | Heat of: | } | | | | |
| Energy | Combustion, cel/gm | 2642 | | | | |
| Underground: Peak Pressure | Hydrolysis, % Acid: | | | | | |
| Impulse | 10 days at 22° C | 0.018 | | | | |
| Energy | 5 days at 60°C | 0.115 | | | | |
| | | | | | | |
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Metriol Trinitrate (MTN) Liquid

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Preparation:

Metricl (trimethylolmethylmethane) is obtained by the following procedure, based on work by Hosaeus (Annalen $\underline{276}$, $\underline{76}$ (1893):

Into a 5 liter round bottom flask 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 oxalate is filtered off, and the pale-yellow filtrate concentrated as much as possible on the steam bath to a thick lemon-yellow syrup. After dissolving in ebsolute alcohol, the solution is filtered and concentrated in the steam bath to about twice the volume of the concentrated syrup. 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 melting point of the product (hO_{10} , gm) is then about 196°C (Hosaeus gives 199°C).

Metricl is nitrated by carefully mixing it with 3.5 parts of 65/35 HNO₃/R₂SO₄ maintained at 20°C, stirring for 30 minutes, cooling to 5°C, and pov ing 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 minute rate of loss in weight is attained. The yield is 88% of the theoretical. The yroduct 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 "mstriolo." A German Patent of 1927 also describes the preparation and gives some properties. This compound was known in France before World War II under the name of "Nitropentaglycerin" and Burlot and Thomas determined its heat of combustion (Ref b).

References: 44

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

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

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

44See footnote 1, page 10.

Minol-2

AMCP 706-177

| Composition: % | Molecular Weight: | 71 | |
|-----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------|--|
| Ammonium Nitrate 40 | Oxygan Balance; CO ₂ % CO % | - 38 - 20 | |
| TNT 40 | | .62-1.68 | |
| Aluminum 20 | Density: gm/cc 1 Malting Point: *C | .02-1.00 | |
| | | | |
| C/H Ratio | Freezing Point: *C | | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 35 | Boiling Point: *C | | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 13 Sample Wt, mg 17 | Refrective Index, n <u>n</u> nii nii nii | | |
| Friction Pendulum Test: Steel Shoe Fiber Shoe | Vocuum Stability Test: cc/40 Hrs, at 90°C | | |
| Rifle Bullet Impact Test: Trials % Explosions Partials Burned Unaffected | 100°C 120°C 135°C 150°C | 2.1 | |
| | 200 Gram Bomb Sand Test: Sand, gm | | |
| Explosion Tempersture: *C Seconds, 0.1 (no cap used) 1 5 Ignites: 435 10 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryl | | |
| 15 20 | Ballistic Mortar, % TNT: (a) | 143 | |
| | Treuzi Test, % TNT: (b) | 165 | |
| 75°C laternational Heat Test: % Loss in 48 Hrs | Plete Dont Test: (c) Method | В | |
| 100°C Heet Test: % Loss, 1st 48 Hrs % Loss, 2:xd 48 Hrs Explosion in 100 Hrs | Condition Confined Density, gm/cc Brisonce, % TNT | Pressed No 1.73 66 | |
| Flammability Index: 100 | Detenation Rate: (d) Confinement | None | |
| Hygroscopicky: % | Condition Charge Diameter, in. | Cast 1.6 | |
| Veletility: | Density, gm/cc Rote, meters/second | 1.68 5820 | |

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AMCP 706-177

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Minol-2

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| Beester Sensitivity Test: Condition Tetryl, gm Wax, in. for 50% Detonation Wax, gm | (e) Pressed 100 1.46 | Decomposition Equation: Oxygen, atoms/sec (Z/sec) Heat, kilocalorie/mole (AH, kcal/mol) Temperature Range, *C |
|-----------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Density, gm/cc | 1.74 | Phose |
| Nest of: Combustion, cal/gm Explosion, cal/gm Gas Volume, cc/gm Formation, cal/gm Fusion, cal/gm | (f) 3160 1620 | Armer Plate Impect Test: (1) 60 mm Morter Projectile: 50% Inert, Velocity, ft/sec 828 Aluminum Fineness 500-lb General Purpose Bombs: |
| Specific Hest: cal/gm/*C At -5°C Density, gm/cc | 0.30 1.74 | Plate Thickness, inches () 1 1 1 1 1 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 |
| Burning Rate: cm/sec | | Bomb Drop Test: |
| Thermal Conductivity; col/sec/cm/°C Density, gm/cc | (b) 16.5 x 10 ⁻⁴ 1.7 ⁴ | T7, 2000-Ib Semi-Armer-Pic/cing Bemb vs Concrete: |
| Coefficient of Expension: Linear, %/*C | | Max Safe Drop, ft 500-16 General Purpose Bankb vs Concrete: |
| Volume, %/°C | | Height, ft Trials |
| Hardnots, Mohs' Scale: | | Unaffected Low Order |
| Young's Medulus: E', dynes/cm² E, ib/inch² Density, gm/cc | (b) 10 5.03 x 10 0.73 x 10 1.66 | High Order 1000-Ib General Purpose Bomb vs Generate: |
| Comprossive Strangth: Ib/inch ² (b) Density, gm/cc Vapor Pressure: *C mm Mercury | 1910-2070 1.68 | Height, ft Trials Unaffected Low Order |
| *C mm Mercury | | High Order |

Mino'.-2

AMCP 706-177

| Frequentation Test: | | Shaped Charge Effectiveness, TNT = 100: | | |
|--------------------------------------------------------------------|---------|----------------------------------------------------------------------------------|--------|--|
| 90 mm HE, M71 Projectile, Let Density, gm/cc Charge Wt, lb | WC-91: | Glass Cones Steel Cones Hole Volume Hole Depth | | |
| Tatai Na. of Fragments: For TNT | | Color: Grsy | | |
| For Subject HE | | | | |
| 3 inch HE, M42A1 Projectile, Le Density, gm/cc Charge Wt, ib | ŵ KC-3: | Principal Uses: Bombs and depth charges | | |
| Teisl No. of Fragments; For TNT | | Mathod of Loading: Cast | | |
| For Subject HE | | Loading Density: gm/cc 1.62-1.68 | | |
| Fregment Velocity: ft/sec At 9 ft | | | | |
| At 251/2 ft | | Storega: | | |
| Density, gm/cc | | Method Day | | |
| Blast (Relative to TNT): | | Hozard Class (Quantity-Distance) Class | 8 | |
| Air: | | Compatibility Group Group | I | |
| Peak Pressure | 115 | | | |
| Impuise | 116 | Exudation | | |
| Energy | 133 | | | |
| Air, Confined: Impulse | 90 | Preparation: Minol is a castable mixture consist: | | |
| Under Water: | | 40 percent INT, 40 percent ammonium ni and 20 percent powdered aluminum and 4 | trate, | |
| Peak Pressure | 108 | fore can be prepared by adding the dry | / in= | |
| Impulse | 126 | gredients to rolten TNT at 90°C under tion. Minol slso can be prepared by | | |
| Energy | 140 | 25 parts of aluminum to 100 parts of 5 | | |
| Underground: Peak Pressure | 134 | amatol previously prepared. | | |
| Impulse | 139 | | | |
| Energy | 1117 | | | |
| | | | | |

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AMCP 706-177

Minol-2

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Origin:

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

| Composition, S: | 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, 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, Table of Military High Explosives, Second Revision, NAVORD Report No. 87-46, 26 July 1946.

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

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

(f) Committee of Div 2 and 8, NDRC, Report on HBX and Tritonal, 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 Picstinny Arsenal Technical Reports on Minol-2: 1585 and 1635.

45See footnote 1, page 10.

MOX-1

AMCP 706-177

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| Composition: | | Malacular Weight: | | 40.6 |
|---------------------------------------------------------------|------------|-----------------------------------|-----------|---------------------------------|
| Oxidizin, agent (Ammonius | | Oxygen Belence: | | |
| Perchlorate) | 35.0 | CO, % | | -44 |
| Aluminum, atomized Cupric Oxide | 26.2 | CO % | | -37 |
| Magnesium, atomized | 26.2 | Dunckty: gm/cc | Pressed | 2.0 |
| Other ingredient (Netryl) Celcium Stearate | 9•7 1•9 | Molting Point: *C | | |
| Graphite, artificial C/H Rotto | 1.0 | Freezing Point: *C | | |
| | | | | <u></u> |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | . | | | |
| Sample Wt 20 mg | 13 | Refrective Index, nm | • | |
| Picatinny Arsenal Apparatus, in. Semple Wt, mg | 13 | n <u>2</u> | • | |
| | ** | n <mark>o</mark> | | |
| Priction Pendukum Yest: | | Vecuum Stobility Test: | | |
| Stuel Shoe | Detonates | cc/40 Hrs, at | | |
| Fiber Shoe | Unaffected | 90°C | | |
| Bills Butlas for an Real and Real | | 100°C | | 0.47 |
| Rifle Bullet Impact Test: Trials | | 120°C | | |
| % Explosions | | 135°C | | |
| Porticis | | 150°C | | |
| Burned | | | | |
| | | 200 Grem Bomb Send Test | 8 | 10.6 |
| Unaffected | | Sand, gm | | T0.0 |
| Explosion Temperature: 'C | | Sensitivity to Initiation: | | |
| Seconds, 0.1 (no cap used) | | Minimum Detanating Ci | harge, gm | |
| 1 | | Mercury Fulminate | | |
| 5 285 | | Lead Azide | | 0.20 |
| 10 | | Tetryl | | 0.25 |
| 15 | | Ballistic Mortor, % TNT: | | فيعدد والمتعالية المحجب والمتعا |
| 20 | | Trunzi Test, % TNT: | | |
| 75'C International Haat Test: | | Plate Dent Test: | | <u> </u> |
| % Loss in 48 Hrs Discoloration, fumes, odor | None | Method | | |
| a na sana ang ang ang ang ang ang ang ang ang | None | Condition | | |
| 100°C Hast Test; | | Confined | | |
| % Loss, 1st 48 Hrs | 0.10 | Density, gm/cc | | |
| % Loss, 2nd 48 Hrs | C.01 | | | |
| Explosion in 100 Hrs | None | Brisonce, % TNT | | |
| Flammability Index: | | - Detenction Rate: Confinement | | |
| Hygroscopicity: % | | Condition Charge Diameter, in. | | |
| | | Density, gm/cc | | |
| Veletility: | | Rate, meters/second | | |

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<u>MOX-1</u>

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| regmentation Test: Shaped Charge Effectiveness, TNT = 100: | | |
|------------------------------------------------------------|------------------------------------------------------------------------------------------|--|
| 90 mm HE, M71 Projectike, Lat 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 antisircraft | |
| 3 inch HE, M42A1 Projectile, Let KC-S: | projectiles | |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fragments: | Method of Londing: Pressed | |
| for TNT | | |
| For Subject ME | Looding Density: gm/cc | |
| Fregment Velocity: ft/sec | At 30,000 pmi ~ 2.0 | |
| AIGH | | |
| At 2514 ft | Storege: | |
| Density, um/cc | Method Dzy | |
| Biust (Relative to TNT): | Hazard Class (Quantity-Distance) Cless 9 | |
| Air: Peak Pressure Impulse | Compatibility Group Group I Bureau of Explosives Classification Class A Exudation | |
| Energy | | |
| Air. Confined: | Heat of: | |
| limpulse | Combustion, cal/gm 4087 | |
| | Explosion, cal/gm 2087 Gas volume, cc/gm 212 | |
| Under Weter: Peak Pressure | | |
| Impulse | Performance Tests: | |
| Enercy | 20 mm T215E1 Projectile: | |
| | NFOC Pressure Cube 35 APC Blast Cube 40 | |
| Underground: Peak Pressure | | |
| Impulse | Activation Energy: | |
| Energy | kcsl/mol 12.5 Temp, C 300 to 380 Time to ignition, seconds 1.78 x 10 ⁻¹ | |
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MOX-2B

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| Composition: % | | Molecular Waight: | 42 |
|-------------------------------------------------------|-------------------------------------------|---------------------------------------------|------------|
| Oxidizing agent (Ammonium | | Oxygen Belance: | |
| Perchlorate) | 35.0 52.4 | | -49 -43 |
| Aluminum, atomized Cupric Oxide | 76.4 | | -+3 |
| Magnesium, atomized | **** | Donsity: gm/cc Pressed | 2.0 |
| Other ingredients* Calcium Stearste | 9.7 1.9 | Melting Point: *C | |
| Graphite, artificial *5.8% RDX and 3.9% TNT coated | 1.0 on <u>Ammonium</u> Perchiorate. | Freezing Point: "C | |
| Impact Sansitivity, 2 Kg Wt: | | Builing Polat: "C | |
| Bureau of Mines Apparotus, cm Sample Wt 20 mg | | Refractive Index, no | |
| Picatinny Arsenal Apparatus, in. | 12 | | |
| Sample Wt, mg | 24 | n | |
| ······································ | | ពង្ហ | |
| Friction Pendulum Test: | | Vecuum Stability Test: | |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| | | - 100°C | 0.21 |
| Rifle Bullet Impect Test: Trials | | 120°C | |
| % Explosions | | 135°C | |
| Partials | | 150°C | |
| Burned | | | |
| Unaffected | | 200 Gram Bomb <u>Sand Test:</u> Sand, gm | 11.5 |
| | | | |
| Explasion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | - | Minimum Detonating Charge, gm | |
| 1 | - | Mercury Fulminate | |
| 5 37 | 5 | Lead Azide | 0.20 |
| 10 | | Tetryl | 0.20 |
| 15 | | Builianic Mamar, % TNT: | |
| 20 | | | |
| 75'C International Heat Test: | | Treuzi Tost, % TNT: | |
| % Loss in 48 Hrs | | Piere Dent Test: | |
| Discoloration, fumes, odor | None | Method | |
| 100°C Heet Test: | | Condition | |
| % Loss, 1st 48 Hrs | 0.27 | Confined | |
| % Loss, 2nd 48 Hrs | 0.12 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisonce, % TNT | |
| | | - Detenstien Kate: | |
| Flemmebility Index: | | Confinement | |
| · | | Condition | |
| Hygruscopicity: % | | | |
| | | Charge Diameter, in. | |
| Volatility: | | Density, gm/cc | |
| • | | Rote, meters/second | |

| AMCP 7 | 06-177 |
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MOX-23

| Fregmentation Test: | | | Shuped Charge Effectiveness, TNT = 100: | |
|--------------------------------|-----------|---------|-----------------------------------------------------|--------------------|
| 90 mm HE, M71 Projectile, La | w WC-91: | | Glass Cones Steel Cones | |
| Density, gm/cc | | | Hole Volume | |
| Charge Wt, Ib | | | Hole Depth | |
| Total No. of Fragments: | | · | u _m i Calar: | |
| For TNT | | | | Grey |
| For Subject HE | | | Principel Uses: HE filler for small os | liber |
| 3 inch HE, M42A1 Projectile, I | Let KC-5: | | projectiles | |
| Density, gm/cc | | | | |
| Charge Wt, Ib | | | | |
| Total No. of Fragmonts: | | | Method of Loading: | Pressed |
| For TNT | | | ······································ | |
| For Subject HE | | | Leading Density: gm/cc | 2.0 |
| Frequent Velocity: ft/sec | | | | |
| At 9 ft At 25½ ft | | | Staroyj: | <u></u> |
| Dansity, gm/cc | | | | |
| | | | Method | Dry |
| Blast (Reistive to TNT): | | • \ | Hazard Class (Quantity-Distance) | Class 9 |
| Air: Dare Charge: | EW# | EV# | Compatibility Group Bureau of Explosives Class A | Group I |
| Peak Pressure | 1.02 | 1.34 | Exudation | None |
| Impulse | 1,00 | T++T / | Excellent | NOUA |
| Energy Density, gm/cc | | 1.96 | | |
| Air, Confined: | | | Heat of: | |
| Impulse | | | Combustion, cal/gm | 4484 |
| Cased Charge in Air:** | | | Explosion, cal/gm | 1472 |
| Peak Pressure | 1.09 | 1.44 | Gas volume, cc/gm | 221 |
| Impulse | 1.16 | 1.53 | Performance Tests: | |
| Energy | | | 20 mm T215E1 Projectile: | |
| Density, gm/cc | | 1.98 | NFOC Pressure Cube | 29 |
| Underground: Peak Pressure | | | APG Blast Cube | 30 |
| Impulse | | | Aviation Energy: | |
| Energy | | | kcal/mol | 7.6 |
| *EW, quivalent weight as | compared | to TNT; | Temp, C 340 to | o 470 |
| EV, equivalent volume as | | | Time to ignition, seconds 1.39 | x 10 ⁻² |
| **Strong paper-base phenoli | le case. | | | |

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MOX-2B

Effect of Altitude, Charge Diameter and Degree of Confinement on Detonation Velocity* (Reference g)

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| | One-In | ich Column | Two-Inch | Column |
|---------------------|-------------|-------------|----------|----------------------------------------|
| Simulated Altitude, | Confined | Unconfined | Confined | Unconfined |
| Feet | . m/# | m/s | m/ # | m/ 6 |
| Ground | | | 4730 | ······································ |
| 30,000 | Charge v | rould not | 4530(3) | Charge would |
| 60,000 | propagate | detonation. | 4430 | not propa- gate detona- |
| 90,000 | 1 7 1 | | 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 initiste each charge.

Average Fragment Velocity at Various Altitudes* (8)

| | | Simulated Altitude, Feet | | | t |
|---------------------|------------------|--------------------------|----------|---------|--------|
| Explosive | Charge Diameter, | Ground | , 30,000 | (%),000 | 90,000 |
| | Inches | m/# | m/ # | m/ 8 | D2/45 |
| MOX-2B, density, | 1 | 2012 | ** | ** | ** |
| gm/cc 207 | 2 | 3314 | 3351 | 3247 | ** |

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

##Charge would not propagate detonation.

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MOX-38

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| Composition: | Moleculer Weight: | 45.6 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|----------|
| Oxidizing agent (Potassium Nitrate) 18 | Oxygen Belence: | |
| Aluminum, atomized 50 | CO ₂ % | -52 |
| Cupric Oxide Magnesium, atomized | CO % | -43 |
| Other ingredients* 32 | Density: om/cc Pressed | 2.0 |
| Calcium Stearate*** 2.0 | Density: gm/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 | <u> </u> |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Boiling Point: *C | |
| Sample Wt 20 mg | Refractive Index, nº | |
| Picatinny Arsenal Apparatus, in. 17 | n ² | |
| Sumple Wt, mg 24 | | |
| ********* | n ² | |
| Friction Pendulum Test: | Vecuum Stability Test: | |
| Steel Shoe Unaffected | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | |
| | - 100°C | 0.57 |
| Rifle Bullet Impact Test: Trials | 120°C | |
| Suplations % | 135°C | |
| Explosions | 150°C | |
| Partials | | |
| Burned | 200 Grem Bomb Sand Test: | |
| Unaffected | Sand, gm | 33.2 |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | |
| 1 . · · · | Mercury Fulminate | |
| 5 540 | Lead Azide | 0.20 |
| 10 | Tetryi | 0.15 |
| 15 | | |
| 20 | Bellistic Morter, % TNT: | |
| 75°C International Heat Test: | Treusl Test, % TNT: | |
| % Loss in 48 Hrs | Plate Dant 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, % TNT | |
| Explosion in 100 Hrs None | · · · · · · · · · · · · · · · · · · · | |
| Flammability Index; | Detonation Rate: | |
| | Confinement | |
| Hygrescopicity: % | Condition | |
| and a second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second second s | Charge Diameter, in. | |
| Valatility | Density, gm/cc | |
| Voletility: | Rate, meters/second | |

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| fragmentation Test: | Shaped Charge Effective | ness, TNT == 100: |
|----------------------------------------|------------------------------------|------------------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: | Glass C | iones at Con . |
| Density, gm/cc | Hole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total No. of Fragmonts: | Color: | Gray powder mixture |
| For TNT | | |
| For Subject HE | | caliber antiaircraft |
| 3 inch HE, M42A1 Projectile, Let KC-5: | proje | otiles |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fragments: | Method of Londing; | Pressed |
| For TNT | - | |
| For Subject HE | Londing Density: gm/cc | |
| regment Velocity: ft/sec | At 30,000 pei | , ~ 2.0 |
| At 9 ft At 25½ ft | Storoge: | |
| Density, gm/cc | ••••• | |
| | Method | Dry |
| last (Relativa to TNT): | Hozard Class (Quanti | ty-Distance) Class 9 |
| Airs | Compatibility Group | Group I |
| Peak Pressure | Bureau | a of Explosives Class A |
| Impulse | | |
| Energy | | |
| Ale, Confined: | Heat of: | |
| Impulse | Combustion, cal, | /gm 4331 |
| Under Weter: | Explosion, cal/g | sm 980 |
| Peak Pressure | Gas volume, co | c/gm 232 |
| Impulse | Performance Tests: | |
| Energy | 20 mm T215E1 Pro | |
| Underground: | NFOC Pressure Cu APG Blast Cube | ibe 37 52 |
| Peak Pressure | | 20 |
| Impulse | Activation Energy: | |
| Energy | kcal/mgl | Values not included |
| | Temp, TC | due to erratic ig- |
| | Time to ignition seconds | n, nition under condi- tions of test. |

AMCP 705-177

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MOX-4B

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| Composition: % | Melecular Weight: 48 |
|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|
| 70 Oxidizing agent (Berium Nitrate) 18 Aluminum, atomized 50 Cupric Oxide Magnesium, atomized | Oxygen Belance: CO ₃ % ~53 CO % -43 |
| Other ingredients [#] 32 Calcium Stearate ^{##} 2.0 | Density: gm/cc Fressed 2.0 |
| Graphite, artificial*** 1.0 | Making Point: *C |
| *29.1% RDX, 0.9% wmx, and 2.0% INT. **Per cent added. | Freezing Point: "C |
| Isspect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 78 | Boiling Paint: "C |
| Sample Wt 20 mg Picatinny Arsenal Apparat is, in. 18 Sample Wt, mg 26 | Rafrective Index, ne ne ne |
| Friction Fendulum Test: Steel Shoe Sparks Fiber Shoe Unsflected | Vocuum Stability Test: cc/40 Hrs, at 90°C |
| Rifie Builot Impact Test: Trials % Explosions Partials | 100°C 0.67 120°C 135°C 150°C |
| Burned Unoffected | 200 Grem Bomb Sand Test: Sand, gm 33.6 |
| Explosion Temperature: *C Seconds, 0.1 (no cop used) 1 5 610 10 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Leod Azide 0.20 Tetryl 0.15 |
| 15 20 | Ballistic Mortar, % TNT: |
| | Trauzi Taut, % TNT: |
| 73°C International Heat Test: % Loss in 48 Hm Discoloration, fumes, odor None | Plate Dant Tast: Method |
| 100°C Heet Test: % Loss, 1st 48 Hrs 0.22 % Loss, 2nd 48 Hrs 0.12 Explosion in 100 Hrs None | Condition Confined Density, gm/cc Brisance, % TNT |
| Fianmability Index: | Detension Rate: Confinement |
| Hygroscopicity: % | Condition Charge Diameter, in. |
| Veietility: | Density, gm/cc Rate, meters/sacond |

| regmentation Test: | Shaped Charge Effectiveness, TNT = 1 | 1001 |
|----------------------------------------|----------------------------------------|----------------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: | | Cones |
| Density, gm/cc | Hole Volume | |
| Charge Wt, Ib | hiole Depth | 8 |
| Total No. of Fregments: | Celur: Gray | powder mixture |
| For TNT | | |
| For Subject HE | Principal Unes: Sumll caliber an | tiaircraft |
| 3 inch HE, M42A1 Projectile, Let KC-5: | projectiles | |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fragments: | Mothed of Leading: | Pressed |
| For TNT | ······································ | |
| For Subject HE | | |
| | Leading Donskyr gm/cc At 30,000 psi | ~2.0 |
| egment Velocity: ft/sec At 9 ft | | ~2.0 |
| At 251/2 ft | Storage: | |
| Density, gm/cc | Method | Dry |
| est (Reletive to TNT): | Hazard Class (Quantity-Distance) | Class 9 |
| Air: | Compatibility Group | Group I |
| Peak Pressure | Bures | u of Explosives |
| Impulse | | Class A |
| Energy | | |
| Air, Confined: | Heat of: | |
| Impulse | Combustion, cal/gm | 4392 |
| Under Weter: | Explosion, cal/gm | 709 |
| Peak Pressure | Gas volume, cc/gm | 208 |
| Impulse | Performance Tests: | |
| Energy | 20 mm T215E1 Projectile: | |
| Underground: | NFOC Pressure Cube APG Blast Cube | 43 53 |
| Peak Pressure | | / / |
| Impulse | Aviation Energy: | [|
| Energy | kcal/mol Values Temp, C due to | not included |
| | | erratic igni- nder conditions t. |

AMCP 706-177

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MOX-6B

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| Composition: | | Melecular Weight: | 43 |
|---------------------------------------------------------------|--------------------|---------------------------------|------------|
| % Oxidizing agent | **** | Oxygen Bulance: | |
| Aluminum, atomized | 49.2 | CO: % | -50 -42 |
| Cupric Oxide | 19.7 | CO % | -42 |
| Magnesium, atomized Other ingredients* Calcium Stearate | 29.6 | Density: gm/cc | |
| Graphite, artificial *28.7% RDX coated, 0.9% wax. | 1.5 | Maining Point: "C | |
| C/H Ratio | | Freezing Point: *C | |
| Impact Sunsitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 78 | Boiling Point: "C | |
| Sample Wt 20 mg | | Refrective Index, ng | |
| Picatinny Arsenal Apparatus, in. | 19 | 02 | |
| Sample Wt, mg | 27 | | |
| | | n | |
| Friction Pandulum Test: | | Vacuum Stability Test: | |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifle Bullet Impact Test: Trials | | - 100.0 | 0.43 |
| 46 | | 120°C | |
| % Explosions | | 135°C | |
| Partials | | 150°C | |
| Burned | | 200 Grem Bomb Sand Test: | <u> </u> |
| Unoffected | | Sand, gm | 10.8 |
| | | | |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, ym | |
| 5 510 | | Mercury Fulminate | **** |
| - / | | Leod Azide | 0.20 |
| 10 | | Tetryl | 0.16 |
| 15 | | Ballistic Morter, % TNT: | |
| 20 | | Trougi Test, % TNT: | |
| 75°C International Host Test: | | Pletu Dent Test: | <u></u> |
| % Loss in 48 Hrs Discoloration, fimes, odor | 0.02/10 gm None | Method | |
| 100°C Heet Test: | ······ | Condition | |
| % Loss, 1st 48 Hrs | 0.00 | Confined | |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/nc | |
| Explosion in 100 Hrs | None | Brisance, % TNT | |
| Flammability Index: | | Detenation Rate; Confinament | |
| | | - Condition | |
| Hygroscopicity: % | 0.70 | Charge Diameter, in. | |
| 30°C, 90% RH, two weeks | 0.79 | Density, gm/cc | |
| Voletility: | | Rate, meters/second | |

AMCP 736-177 MOX-6B Shaped Charge Effectiveness, TNT = 100: Enginemiation Test: 90 mm HE, M71 Projectile, Lot WC-91: Glass Cones Steel Conas Density, gm/cc Hole Volume Hole Depth Charge Wt, .1b Total No. of Fragments: Gray powder mixture Celer: For TNT! For Subject HE Principal Uses: Small caliber antisircraft projectiles 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib **Total No. of Fragments:** Method of Locding Pressed For TNT For Subject HE Louding Density: gm/cc At 30,000 pei ~2.0 Fregment Velesity: ft/sec At 9 ft At 251/2 ft Storage: Density, gm/cc Dry Method Class 9 Hazard Class (Quantity-Distance) Biest (Relative to TNT): **Compatibility Group** Group I Air: Bureau of Explosives Peak Pressure Class A Impulse Energy Heat of: Air, Conflued: Impulse Combustion, cal/gm 4293 750 204 Explosion, cal/gm **Under Weter:** Gas volume, cc/gm Pask Pressure Activation Energy: Impulse kcel/mol Energy Values not included Temp, C Time to ignition, due to erratic igni-Underground: tion under conditions Peak Pressure seconds of test. Impulse Energy

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AMCP 706-177

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

Preparation:

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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°C under mechanical agitation. Six hundred grams of the atomized aluminum powder is added gradually (2 to 3 minutes) and stirring ls 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-wet product is then dried in an oven at 50°C. The dried material is hand-rolled to reduce any conglomerates, and blended before use.

Wax-Coated RDX - Eighteen grams of molten Be Square Special Wax (manufacturer's 190° to 185° Fahrenheit grade amber) is added to 582 grams of finely divided RDX (water precipitated from ocetone solution) in a water slurry under mechanical sgitation. The temperature of the wax-RDX slurry is maintained above the melting point of the wax (about 90 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 hand-rolled to crush any conglowerates formed, and blended 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 agits cion. 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 and before use.

INT-Costed Potassium Nitrate - The INT-costed potassium nitrate is prepared by the same procedure as is used for costing barium nitrate.

<u>RDX/TNT-Coated Annonium Perchlorate</u> - The annonium perchlorate is coated by dissolving the suppropriate weights of RDX and TNT in hot alcohol. After adding the summonium perchlorate, the slurry is stirred until most of the solvent is evaporated. The treated annonium perchlorate is spread on a tray to dry overnight. Agglomerates formed during the process are crushed by hend-rolling and blending the mixture before use.

<u>THT-Coated RDX</u> - Sixty grams of molten TNT are added to a water slurry of 540 grams of finally divided RDX (water precipitated from acctone solution) under mechanical agitation. The temperature of the TNT-RDX slurry is maintained at about 90°C and stirring is continued for half an hour. After cooling to about 50°C, the TNT-coated RDX is recovered by filtration. The RDX thus treated, and presumed to be 10% coated or a 90/10 RDX/TNT mixture, is further blended by hand after rolling to crush any aggregates formed during the process.

The MOX explosive mixtures are prepared by blending the appropriate weights of the dry in; redients in a Patterson-Kelly twin-shell blender for at least 30 minutes.

Origin:

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

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

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(b) A. T. Wilson, <u>Development of MOX Explosives</u>: <u>Various Oxidants in MOX</u>, 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 Fireworks 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 MOX Explosives</u>: <u>Composition Variations</u>, First Progress Report NFOC-7, Navy Contract NOrd-12382, National Fireworks Ordnonce Corporation, 1952.

(f) A. T. Wilson, <u>Development of MOX Explosives</u>; Various Oxidants in MOX, 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> <u>Velocity Determinations and Fragment Velocity Determinations of Varied Explosive Systems</u> <u>and Conditions</u>, National Northern Corporation Final Summary Report NNC-F-13, February 1958 (Contract DAI-19-020-501-ORD-(P)-58).

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

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

⁴⁶See footnote 1, page 10.

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Mitrocellulose, 12.6% N (NC)

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| Composition: | Molocular Weight: (272, 39), | 1 |
|-------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|----------|
| C 26.46 H 2.78 H $_2$ C H X N 12.60 X H H | Oxygen Belence: CO ₂ % -35 CO % 0.6 | |
| 0 58.16 x• 0NO2 | Density: gm/cc | |
| | Meiting Point: "C Decomposes | |
| C/H Ratio 0.23 | Freezing Point: "C | |
| Impect Sensitivity, 2 Kg Wt: | Boiling Paint: *C | |
| Bureau of Mines Apparatus, cm B Sample Wt 20 mg Picatirny Arsenal Apparatus, in. 3 Sample Wt, mg 5 | Refractive Index, ng ng ng ng | |
| Friction Pandulum Tost: | Yacuum Stability Test: | |
| Steel Shoe | cc/40 Hrs, at 90°C 0.17 | |
| Fiber Shoe | | |
| Rifle Bullet Import Tast: Trials | 120°C 16 hours 11.+ | |
| % | 135°C | |
| Explosions | 150°C | |
| Partials Burnet | | <u> </u> |
| Burned Unaffected | 200 Grem Bomb Sand Test: Sand, arr. 45.0 | |
| | Sond, gm 45.0 | |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | |
| l 5 Decomposes 170 | Mercury Fulminate | |
| 10 | Lead Azide 0.10 | |
| 15 | Tetryl | |
| 20 | Ballistic Morter, % TNT: | |
| | Trouzi Test, % TNT: | |
| 75°C Internetional Heat Test: % Loss in 48 Hrs | Plate Deut 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 | |
| | Detenation Rate: | |
| Flemmability Index: | Confinement | |
| | Condition | |
| Hygroscopicity: % 30°C, 90% RH 3 | Charge Diameter, In. | |
| | Density, gm/cc | |
| Veletility: 60°C, mg/cm ² /hr 0.0 | Rote, meters/second | |

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Nitrocellulose, 13.45% N (NC)

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| Composition: H o' | Molocular Weight: | (286.34) _n |
|-----------------------------------------------------------------|----------------------------|-----------------------|
| с 25.29 Х.н | Oxygen Belence: | |
| H 2.52 H ₂ C- | CO, % | -29 |
| N 13.45 X H A | CO % | 4.7 |
| o 58.74 o x | Density: gm/cc | |
| н | Melting Point: "C | Decomposes |
| C/H Ratio 0.23 | Freezing Point: *C | |
| Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 9 | Boiling Point: "C | |
| Somple Wt 20 mg | Refractive Index, no | |
| Picatinny Arsenal Apparatus, in. 3 | nB | |
| Sample Wt, mg 5 | nª | |
| | | |
| Friction Pendulum Test: | Vocuum Stability Test: | |
| Steel Shoe | cc/40 Hrs, at | 0.42 |
| Fiber Shoe | 90°C | |
| Rifle Bullet Impact Test: Trials | | 1.5 |
| % | 120°C | 11.+ |
| 50 Explosions | 135°C | |
| Partials | 150°C | |
| Burned | 200 Grem Benik Send Test: | |
| Unaffected | Sand, gm | 49.0 |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge | r, gm |
| 1 | Mercury Fulminate | |
| 5 230 | Lead Azide | 0.10 |
| 10 | Tetryl | |
| 15 | | |
| 20 | Bellistic Morter, % TNT: | 125 |
| 73°C Internetional Heat Test: | Treuzi Test, % TNT: | |
| % Loss in 48 Hrs | Plate Dent Test: Method | |
| .100°C Heet Test: | Condition | |
| % Loss, 1st 48 Hrs 0.3 | Confined | |
| % Loss, 2nd 48 Hrs 0.0 | Density, gm/cc | |
| Explosion in 100 Hrs None | Brisance, % TNT | |
| | Defunction Rate: | |
| Flemmebility Index: | Confinement | |
| | Condition | |
| Hygroscopicity: % 30°C, 90% RH ~2 | Charge Diameter, in. | |
| | Density, gm/cc | 1.20 |
| Veletility: 60°C, mg/cm ² /hr 0.0 | Rate, meters/second | 7300 |

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Nitrocollulose, 14.14% N (NC)

| Composition: | Melecular Weight: | (297.15) _n |
|-------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------|-----------------------|
| $\begin{array}{c} & & \\ C & & 24.25 \\ H & & 2.77 \\ N & & 14.14 \end{array} \xrightarrow{H_2C} H \\ & & \\ X \\ & & \\ X \\ & \\ \end{array}$ | Oxygen Belance: CO4 % CO % | -24 8 |
| 0 59.24 X=0N0 ₂ | Density: gm/cc 1. | 65-1.70 |
| | Matting Point: 'C Dec | ощровев |
| C/H Rotio 0.23 | Freezing Point: *C | |
| Import Sensitivity, 2 Kg Wt: Bureou - i Mines Apparatus, cm - 8 | Bailing Polet: *C | |
| Sample Wt 20 mg | Refractive Index, no | |
| Picatinny Arsenal Apparatus, in. 3 Sample Wt, mg 5 | ពដ្ឋ | |
| | n ₂ | ļ |
| Friction Pendulum Test: | Vacuum Stability Test: | |
| Steel Shoe | cc/40 Hrs, at | 2.10 |
| Fiber Shoe | 90°C 100°C 14 hours | 1.46 11.+ |
| Rifle Bullet Impact Test: Trials | | 11.+ |
| ~ % | 135°C | |
| Explosions | 150°C | |
| Partials Burned | | |
| Unaffected | 200 Grew Bomb Send Test: Sand, gm | 50.0 |
| | | 52.3 |
| Explosion Temperatury: "C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) 1 | Minimum Detonating Charge, gm Mercury Fulminate | |
| 5 | Lead Azide | 0.10 |
| 10 | Tetryl | |
| 15 | | |
| 20 | Bullistic Mortur, % TNT: | |
| | Trouxi Test, % TNT: | |
| 75°C International Haat Test: % Loss in 48 Hrs | Plata Dant Test: | |
| | Method | |
| 100°C Heat Test: | Condition | |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc Brisance, % TNT | |
| Explosion in 100 Hrs | | |
| Flammability Index: | Detention Rate: Confinement | |
| Hygroscopicity: % 30°C, 90% RH → 1 | Condition Charge Diometer, i | |
| Veletility: 60°C, mg/cm ² /hr 0.0 | Density, gm/cc Rate, meters/second | |

Nitrocellulose (NC)

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| Fragmentation Test: | Shapod Charge Effectiveness, YNT == 10G. |
|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, Ib | Glass Cones Steel Cones Hole Volume Hole Depth |
| Total No. of Fragments: For TNT | Celer: White |
| For Subject HE 3 inch HE, M42A1 Projectile, Lat KC-3: Density, gm/cc Charge Wt, Ib | Principal Uses: Pyroxylin (12% N), blasting explosives; pyrocellulose (12.60% N), suckeless powder; guncotton (13.35% N minimum), propellants |
| Total Na. of Fragments: For TNT For Subject HE | Method of Looding: |
| | Looding Density: gm/cC |
| Fregment Volecity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Storage: Method Wet (8% to 30% weter) |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) Class 12 |
| Air: Peak Pressure Impulse Energy | Compatibility Group Group M (vet) Exudation None |
| Air, Confined: Impulse Under Water: Peak Pressure | Heat of: Combustion, cal/gm 2409* 2313** 2228*** Explosion, cal/gm 855* 965** 1058*** Gas Volume, cc/gm 919* 883** 853*** Formation, cal/gm 617* 561*** 513*** |
| Impulse Energy | * 12.6% N ** 13.45% N *** 14.14% N |
| Underground: Peak Pressure Impulse Energy | Vapor Pressure: 0 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°C 60°C | Insolubla Insoluble | Insoluble Insoluble | Insoluble Insoluble |
| Solubility, gm/100 gm, 25°C, in: | | 1 | |
| Ether Alcohol | Insoluble Very slight- ly soluble | insoluble | Insoluble Insoluble |
| 2:1-Ether:Alequol | Soluble | Slightly soluble (6%-11%) | Practically insoluble (1 + %) |
| Acetone | Soluble | Soluble | Soluble |
| 240-Hour Hydrolysis Test, % Nitric Acid | 1.22 | 1.03 | |

Preparation of Nitrocellulose from Cotton Linters; (Laboratory Procedure)

<u>Nitration:</u> 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: H2SO4 63.5%, HNO3 21%, H20 15.5%
- b. for 13.4% N: H2SOL 68%, HNO3 22%, H2O 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 repidly 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 nitrocellulose-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>Posching:</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 sodium carbonate solution is added to maintain the mixture faintly sixeline to phenolphthalein. The water is decanted and the boiling continued. According to the specification, the total boiling treatment with posching 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° 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. Mitrocellulose was discovered about 184γ by C. F. Schonbein at Basel and 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.

<u>Pyroxylin</u> or collodion, which is soluble in a mixture of ether and ethenol, contains from 8% to 12% nitrogen. It is used in the manufacture of celluloid and in composite blasting explosives.

<u>Pyrocellulose</u>, a type of nitrocellulose of 12.64 nitrogen content, completely soluble in a mixture of 2 parts other and one part ethanol, was developed by Mendeleev (1891-1895). This material, when colloided, formed the first smokeless powder for military use in the United States (1898).

<u>Guncotton</u> for military purposes today contains a minimum of 13.35% nitrogen. It is only elightly 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 (blended nitrocellulose) of 13.15% to 13.25% nitrogen content.

Destruction by Chemical Decomposition:

Nitrocellulose is decomposed by adding it, with stirring, to 5 times its weight of 10% sodium hydroxide heated to 70° C. Stirring is continued for 15 minutes after all the nitro-cellulose has been added.

References: 47

(a) See the following Picatinny Arsenal Technical Reports on Nitrocellulose:

47See footnote 1, page 10.

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Nitrocellulose (NC)

| <u>0</u> | 1 | 2 | 3 | <u>14</u> | ٤ | 6 | ĩ | <u>8</u> | 2 |
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| 10 380 420 660 730 960 1020 1100 1210 1240 1300 1320 1320 1320 1320 1320 1320 132 | $\begin{array}{c} 41\\ 101\\ 231\\ 351\\ 831\\ 971\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 1031\\ 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14399 16199 1809 99 1809 99 1159 12309 13299 13399 14399 16199 1809 1809 1809 1809 1809 1809 1809 1 |

Nitroglycerin (Liquid)

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| Composition: % | Molecular Weight: (C ₂ H ₅ N ₃ O ₉) 227 |
|--------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|
| C 15.9 $H_2C - 0NO_2$ H 2.2 $HC - 0NO_2$ | Oxygen Belance: 3.5. CO ₃ % 24.5 |
| $\begin{array}{c} n \\ n \\ n \\ n \\ n \\ n \\ n \\ n \\ n \\ n $ | Density: gm/cc 25°C, Liquid 1.591 20°C, Liquid 1.596 |
| $n_{2} = 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0 + 0$ | Meiting Point: *C Labile form 2.2 Stable form 13.2 |
| C/H Ratio 0.109 | Freazing Point: "C |
| Impact Sansitivity, 2 Kg Wt: | Beiling Point: °C Decomposes 145 |
| Bureau of Mines Apparatus, cm 15 Sample Wt 20 mg | Refractive Index, no. 1.4732 |
| Picatinny Arsenai Apparatus, in, 1 15 wt 1 Sample Wt, mg | ດີ 1.4713 ກະ |
| Friction Pendulum Test: | Vacuum Stability Test: |
| Steel Shoe Explodes | cc/40 Hrs, at 90°C cc/gw/6 hrs 1.6 |
| Fiber Shoe | 90°C cc/gm/6 hrs 1.6 |
| Rifie Builet Impact Test: Trials | 120°C |
| % Explosions 100 | 135°C |
| Partials 0 | 150°C |
| Burned 0 | 200 Grem Bomb Sund Test: |
| Unaffected 0 | Sand, gm Idquid method 51.5 |
| Explosion Temperature: °C Seconds, 0.1 (no cap used) 1 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryi |
| 20 | Ballistic Mortur, % TNT: (a) 140 |
| | _ Treuzi Test, % TNT: (b) 181 |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dont Test: Method |
| 100°C Heet Test: | - Condition |
| % Loss, 1st 48 Hrs 3.6 | Confined |
| % Loss, 2nd 48 Hns 3.5 | Density, gm/cc Brisance, % TNT |
| Explosion in 100 Hrs None | |
| Flemmability Index: | - Detension Refe: Confinement Glass Steel |
| | Condition Idquid Idquid |
| Hyproscepicity: % 30 ⁰ rt, 00% Bit 0.06 | |
| Hygrescepicity: % 30°C, 90% RH 0.06 Veletility: 60°C, mg/cm ² /hr 0.11 | Charge Diameter, in. 0.39 1.25 Density, gm/cc 1.6 1.6 |

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Nitroglycerin (Liquid)

| Beester Sensitin Condition | my test: | | Decomposition Equation: | 17 . | ••••••••••• |
|------------------------------------------------|--------------------------------|------------|--------------------------------|--------------------|--------------------|
| Tetryl, gin | | | Oxygen, atoms/sec (Z/sec) | 10 ^{17.3} | 10 ^{19.2} |
| | 50% Detonation | | Heat, kilocalorie/male | 41.4 | h.e. • |
| Wax, gm | | | (AH, kcal/mol) | | 45.0 |
| Density, gm/ | cc | | Temperature Range, *C Phase | 90-135 Liquid | 125-150 |
| Heat of: | | • | | mrdar a | Liguið |
| Combustion, | cai/gm | 1616 | Armer Plate Impact Test: | | |
| Explosion, cal | /gm | 1600 | | | |
| Gas Volum | | 715 | 60 mm Morter Projectile: | | |
| Formation, ca | | 400 | 50% inert, Velocity, ft, | /sec | |
| Fusion, cal/a | n | 700 | Aluminum Fineness | | |
| Detonation | , cal/gm | 1486 | . 500-lb General Purpose Bo | mbe. | |
| Specific Hent: co | al/gm/*C | | | ***** | |
| Liquid | | 0.356 | Plate Thickness, inches | | |
| Solid | | 0.315 | 1 | | |
| | | (AC +0 | 11/2 | | |
| | | | 114 | | |
| Russian # . | | | 1.74 | | |
| Burning Kets: cm/sec | | | - /• | | |
| | | | Somb Drap Test: | | ····· |
| Thormal Conduct | ivity: | | | | |
| cal/sec/cm/*C | 1 | | 77, 2000-16 Semi-Armer-Pi | ercing Bomb vs | Concrete: |
| Coefficient of Exp | ensions | | Max Safe Drop, ft | | |
| Linear, %/*C | | | 500-ib General Purpose See | | |
| Volume, %/*C | | | | WE VE GORCIEN | |
| Manfanan berber | | | Height, ft Triols | | |
| Hardness, Mohs' S | icale) | | Unaffected | | |
| Young's Modulus: | | | Low Order | | |
| E', dynes/cm ² | | | High Order | | |
| E, Ib/inch ² | | | High Uroll' | | |
| Density, gm/cc | | | 1000-lb General Purpose Bor | wb vz Concrete | : |
| | the indirects | | Height, ft | | |
| Compressive Steam | | 1 | Trials | | |
| Compressive Streng | | 1 | | | |
| | | | Unaffected | | |
| lapar Pressure: | | | Low Order | | |
| C ma Merc | ury <u>°c</u> | mn Mercury | | | |
| C ma Merc | <u>ury ⁹c</u> 60 | 0.0188 | Low Order | | |
| Vapor Pressure: C <u>ma Merc</u> 0.00025 | <u>ury ⁹C</u> 60 | | Low Order | | |

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Nitroglycerin (Idquid)

AMCP 706-177

| Frugmentation 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 | Colorless |
| For Subject HE 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, ib | Principel Uses: Propellant ingredient, demoli- tion explosive ingredient, grenade burster ingredient |
| Total Ne. of Fragments: For TNT | Method of Londing: |
| For Subject HE | Loading Density: gm/cc |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft | Sterege: |
| Density, gm/cc | Method With acetone or other desensitizer generally not stoled |
| liast (Relative to TNT): | Fazard Class (Quantity-Distonce) Class 9 |
| Air: Peak Pressure | Compatibility Group |
| Impulse Energy | Exudation |
| Air, Confined: impulse | Heat of Transition, cal/gm; Transition: |
| Under Weter: Peak Pressure | Liquid> labile 5.2 Labile> stable 28.0 Liquid> stable 33.2 |
| Impulse Energy | Hydrolysis, % Acid: |
| Underground: Peak Pressure | 10 days at 22°C < 0.002 5 days at 60°C 0.005 |
| impulse Energy | 82.1°C KI 1est: Minutes 10+ |
| | |
| | |

AMCP 705-177

Nitroglycerin (Liquid)

Gas Evolved at Atmospheric Pressure, cc:

| Sample Wt, gm | 1 | 6 |
|-------------------|-----|--------------|
| Temperature, °C | 65 | 75 40 |
| Time, hours | 20 | 40 |
| Volume of gas, cc | nil | n ± 1 |

Viscosity: (c)

| °c | Centipoises |
|----|-------------|
| 10 | 69.2 |
| 20 | 36.0 |
| 30 | 21.0 |
| μõ | 13.6 |
| 50 | 9.4 |
| 60 | 6.8 |

Fragmentation Test:

20 mm HE, Mark 1, Projectile, Total No. of Freguents for:

22 17 Nitroglycerin

Minimum Propagating Diameter: (d)

| <u>% Dimethylphthalate</u> <u>in NG</u> | Min. Propagating Diameter, inches | Maximum Dismeter for 2 Failures in 2 Trials, inches |
|--------------------------------------------|--------------------------------------|-----------------------------------------------------------|
| 0 | (3/16 Cairns) | 1/16 |
| 5 | | 1/8 |
| 10 | 1/8 | 3/16 |
| 15 | 1/4 | 3/8 |
| 20 | 3/4 | 7/8 |
| 22.5 | 1 | 1-1/2 |
| 25 | 1.55 | 2 |

Sensitivity to Electrostatic Discharge, Joules (test condition, unconfined; no value given for confinement): > 12.5

Solubility, grams of nitroglycerin/100 gm (%) of:

| Water Alcohol | | cohol | Trichlor | ethylene | Carbon Tetrachloride | | |
|---------------|--------------|-----------|----------------|----------|----------------------|----|---|
| °c | <u>ب</u> | °C. | ž | °C | 2 | °C | Ź |
| 15 20 | 0.16 0.18 | () 7,0 | 37•5 54•0 | Rm | 22 | Rm | 2 |
| 50 | 0.25 | 100 | ;; 4 .0 | | | | |

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Nitroglycerin (Liquid)

gm/100 gm (%), at 25°C in

Euner * 2:1,Ether:Alcohol > 100

Acetone

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| Ambient 1 |
|--------------------------------|
| Soluble in all Proportions in: |
| Methanol |
| Acetone |
| Ether |
| Ethyl acetate |
| Anyl acetate |
| Methyl nitrate |
| Ethyl nitrate |
| Nitroglycol |
| Tetranitrodiglycerine |
| Acetic acid |
| Bendane |

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Carbon Disulfide

°C

Pheno1 Pyridine Xylene Nitrobenzene p-Ni trotoluene Idauid DNT Chloroform Ethyl chloride Ethyl bromide Tetrachloroethylene Dichloroethylene Trimethyleneglycol Dinitrate

Solubility in NG, of:

| Alcohol | | D | DNT | | MT | Water | | |
|---------|------------|----|-----|----|----|-----------|------|--|
| °c | ž | °c | ž | °c | ž | <u>°c</u> | ź | |
| 0 20 | 3.4 5.4 | 20 | 35 | 20 | 30 | 25 | 0.06 | |

Preparation:

Toluene

сн₂-0802 - OH -ONO2 + 3HNO3 + 38,0 ·OH CH CD 2 CH2-0402 CH2-

Glycerine is usually nitrated at 25°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 5. Agitation of the reaction mixture is accomplished by use of compressed air. A rapid temperature rise, or appearance of red fumes, automatically 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°C, and the charge is then run into a separator where the NY rises to the top, and is run off to the neutralizer. The nitroglycerin is warhed first with water, then with sodium carbonate, and finally with water. The resultant NO when washed with water, produces washings which do not color phenolphthalein, and itself is neutral to litmus paper.

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Nitroglycerin (Liquid)

Origin:

2

Nitroglycerin was first prepared in 1846 or 1847 by Ascanio Sobrero, an Italian chemist (Mem 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 mothod of initiation (British Patent 1813). Nobel gave the name dynamite to mixtures of nitroglycerin and non-explosive absorbents, such as chercoal, siliceous earth or Kieselguhr (British Patent 1345 (1867)). Later developments led to gelatine dynamites, ammonia dynamites, and so called straight dynamites. The first propellants using nitroglycerin were called Ballistite (Nobel, British Patent 1471 (1888)) and Cord.te (Abel and Davar, British Patents 5614 and 11,664 (1889)).

Destruction by Chemical Decomposition:

Nitroglycerin is decomposed by adding it slowly to 10 times its weight of 18% sodium sulfide (Na₂S.9H₂O). 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. H. Blatt, <u>Compilation of Data on Organic Explosives</u>, OSRD Report No. 2014, 29 February 1944.

- (b) Ph. Naoum, Z ges Schiess-Sprengstoffw, pp. 181, 229, 267 (27 June 1932).
- (c) Landolt Bornstein, <u>Physikalisch-Chemische Tabellen</u>, 5th Ed. (1923).

International Critical Tables.

B. T. Fedoroff et al, A Manual for Explosive Laboratories, Vol I-IV, Lefax Society, Inc., Philadelphia, 1943, 1946.

(d) H. A. Strecker, Initiation. Propagation and Luminosity Studies of Liquid Explosives, OSRD Report No. 5609, 3 December 1945.

| (e |) / | Uso i | see i | the | fol | lowing | Picatinny | Arsens] | . Technical | Rep | orts | QĽ | Nitrogl | ycerin: |
|----|-----|-------|-------|-----|-----|--------|-----------|---------|-------------|-----|------|----|---------|---------|
|----|-----|-------|-------|-----|-----|--------|-----------|---------|-------------|-----|------|----|---------|---------|

| <u>o</u> | 1 | 2 | 3 | <u>4</u> | ٤ | <u>6</u> | I | <u>8</u> | 2 |
|-------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------|----------------------------------------------------------------------|----------------------------------------------------|---------------------------------------------|-------------------------------------------------|
| 620 660 800 1020 1150 1210 1410 1620 1680 | 511 551 701 891 1031 1041 1151 1221 1611 1651 1651 1651 1651 1731 1781 1851 2021 2181 2201 | 652 672 792 922 1142 1362 1542 1662 1692 1742 1992 | 233 343 673 903 1023 1643 1663 1863 1993 | 454 494 1024 1074 1084 1454 1524 1624 1671 1754 | 1155 1235 1955 2015 | 1206 1456 1496 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 |

48See footnote 1, page 10.

Nitroguanidine

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| Composition: | | Melecular Weight: $(CH_4N_4O_2)$ | 1.04 |
|----------------------------------------------------------------------|------------|------------------------------------------------------------|---------|
| C 11.5 NH | ? | Oxygen Balance: CO ₂ % | -31 |
| н 3.9 ни с | | CO % | -15.4 |
| N 53.8 NH | | Density: gm/cc Crystal | 1.72 |
| 0 30.8 NO | 2 | Malting Point: *C | 232 |
| C/H Ratio 0.038 | | Freezing Point: *C | |
| mpoct Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 47 | Boiling Point: *C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg | 26 7 | Refrective Index, nº nº nº | |
| riction Pondulum Test: | (•) | Vecuum Stebility Test: | |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Lifie Bullet Impact Text: 5 Trials | (e) | | 0.37 |
| 96 | \-/ | 120°C | 0.44 |
| Explosions 0 | | 135*C | |
| Portials G | | 150°C | |
| Burned O | | 200 Grow Bomb Sund Test: | |
| Unoffected 100 | | Sand, gm | 36.0 |
| Explosion Temperature: *C Seconds, 0.1 (no cop used) | | Sanskivity to Initiation: Minimum Detonating Charge, gm | |
| 1 | | Niercury Fulminsie | |
| 5 Decomposes 275 | | Lead Azide | 0.20 |
| 10 | | Tatryi | 0.10 |
| 15 20 | | Bailistic Mortur, % TNT: (a) | 104 |
| 40 | • | Truuni Test, % TNT: (b) | 104 |
| S'C International Haat Test: | 0.01 | Plate Dent Tget: (c) | |
| % Loss in 48 Hrs | 0.04 | Method | * |
| IOG'C Heat Tast: | | Condition | Pressed |
| % Loss, 1st 48 Hrs | 0.18 | Confined | No |
| % Loss, 2nd 48 Hrs | 0.09 | Density, gm/cc | 1.50 |
| Explosion in 100 Hrs | None | Brisonce, % TNT | 95 |
| formebility Index; | <u></u> | Detenation Rate: (e) Confinement | |
| tygroscopicity: % 30°C, 90% RH | None | Condition Charge Diameter, in. | |
| Velatility: | None | Density, gm/cc | 1.55 |
| | 11011 | Rate, meters/second | 7650 |

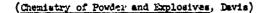
AMCP 706-177

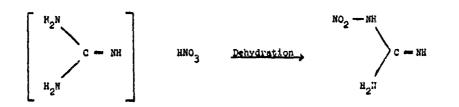
Nitroguanidine

| Fragmentation Test: | Shaped Charge Effectiveness, THT $=$ 100: | |
|---------------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib | Glass Cones Steel Con Hole Volume Hole Depth | H |
| Total Na. of Fregments: Far TNT | Celer: Colorie | |
| For Subject HE | Principal Uses: | |
| 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib | Propellant composition ingredie bursting charge ingredient | nt, |
| Total No. of Fregmentz; For TNT For Subject HE | Method of Loading: | |
| | Loading Density: gm/cc | |
| Fregment Velocity: ft/sec | At 3000 psi | 0.95 |
| At 9 ft At 25½ ft | Storoga: | |
| Density, gm/cc | Method | Dry |
| Blast (Reletive to TNT): | Hazard Class (Quantity-Distance) | Class 9 |
| Air: Peak Pressure | Compatibility Group | Group I |
| Impulse | Exudation | 1 |
| Energy | | |
| Air, Centined: | Solubility, gm/100 gm (%), in: | e l |
| Impulse | Water 25 | 0.44 |
| Under Weter: Peck Prassure | 1.0 N Potassium Hydroxide 25 | 1.2 |
| impulse | 40% Sulfuric Acid 0 | 3.4* |
| Energy | # gm/100 cc solution | 8.0* |
| | Booster Sensitivity Test: | (4) |
| Underground: Peak Pressure | Condition | Pressed |
| Impulse | Tetryl, gm Wax, in. for 50% Detonation | 100 0.67 |
| Energy | Density, gu/cc | 1.41 |
| | Heat of: | |
| | Combustion, cal/gm Explosion, cal/gm Cas Volume, cc/gm Formation, cal/gm | 1995 721 1077 227 |

Nitroguanidine

Preparation:





Four hundred gms of dry guanidine nitrate is added in small portions to 500 cc concentrated sulfuric acid at 10° 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:

Nitroguanidine 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 varming the solution until gas is evolved. Heating is continued for one-half hour.

References: 49

(a) L. C. Smith and E. G. Lyster, <u>Physical Testing of Explosives</u>, 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 RDX/Wax Mixtures as a Substitute for Tetryl in Bousters</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 1955.

⁴⁹See footnote 1, page 10.

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Nitroguanidine

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

| <u>0</u> | <u>1</u> | 2 | 3 | <u>6</u> | I | <u>8</u> | 2 |
|----------|-----------------------|----------------------|----------------------|----------|-------------|----------|--------------|
| 1490 | 1 391 2181 2201 | 1282 1392 2142 | 1183 1423 2193 | 1336 | 907 2177 | 758 | 1439 1749 |

Nitroisobutylglycerol Trinitrate (NIBTN) Liquid

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| Composition: % | Molecular Weight: (C4H6N4011) | 286 | | |
|-----------------------------------------------------|----------------------------------|---------------|--|--|
| | Oxygen Belence: | | | |
| 02 ¹⁰ 012 | CO: % | 0.0 | | |
| H 2.1 $O_2NO-CH_2 \longrightarrow C - NO_2$ | | | | |
| .N 19.6 | Density: gm/cc 20 ⁰ C | 1.64 | | |
| 0 61.5 02NO-CH2 | Maiting Point: *C | | | |
| C/H Ratio 0.126 | Freezing Point: *C | -39 | | |
| Impact Sansitivity, 2 Kg Wt: | Boiling Point: *C | | | |
| Bureau of Mines Apparatus, cm 25 Sample Wt 20 mg | Refractive Index, nº | | | |
| Picatinny Arsenal Apparatus, in. | n0 | | | |
| Sample Wt, mg | | 1.4896 | | |
| | n | 1.4874 | | |
| Friction Pandulum Test: | Vocuum Stability Test: | | | |
| Steel Shoe | cc/40 Hrs, at | | | |
| Fiber Shoe | 90°C | | | |
| Rifle Builet impect Test: Triais | - 100°C | | | |
| | 120°C | | | |
| % Explosions | 135°C | | | |
| Partials | 150°C | | | |
| Burned | 200 Grem Bomb Sand Test: | | | |
| Unaffected | Sand, am 0,2 gu sample absorb | ň. | | |
| | by 0.2 gm of kleselgubr | 28 | | |
| Explosion Temperature: *C | Sensitivity to Initiation: | | | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | | | |
| } 5 Ignites 185 | Mercury Fulminate | | | |
| | Lead Azide | | | |
| 15 | Tetryl | | | |
| 20 | Ballistic Mortor, % TNT: | | | |
| | Trauzi Teet, % TNT: | | | |
| 75°C International Haat Test: % Loss in 48 Hrs | Platu Dent Test: | <u></u> | | |
| | Method | | | |
| 100°C Heet Test: | Condition | | | |
| % Loss, 1st 48 Hrs | Confined | | | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | | | |
| Explosion in 100 Hrs | Brisance, % TNT | | | |
| | Detenation Rute: | | | |
| Flammability Index: | Confinement G1 | as (1 mm vall | | |
| | Condition | Liquia | | |
| Hygreecopicity: % | Charge Diameter, in. | 0.39 | | |
| Veletility: | Density, gm/cc | 1.64 | | |
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Nitroisobutylglycerol Trinitrate (NIBTN) Liquid

| Fregmentation Test: | Shaped Charge Effectiveness, TNT = 100: | | | | |
|------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, ib | Glass Cones Steel Cones Hole Volume Hole Depth | | | | |
| Total No. of Fragmonts: For TNT | Color: Yellow oil | | | | |
| For Subject HE 3 inch HE, M42A1 Projectile, Let KC-3: Density, gm/cc Charge Wt, Ib | Principel Uses: Gelatinizing agent for nitrocellulose | | | | |
| Total No. of Fragments: • For TNT For Subject HE | Method of Looding: Looding Density: gm/cc Storege: Method Liquid Hazard Cluss (Quontity-Distance) | | | | |
| Fragment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | | | | | |
| Blast (Relative to TNT): | | | | | |
| Air: Peak Pressure Impulse Energy Air, Confined: | Compatibility Group Exudation Solubility: Soluble in methyl and ethyl alcohols, ace- | | | | |
| Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure | tone, ether, ethylenedichloride, chloroform and benzene. Insoluble in water, carbon disulphide, and petroleum ether. <u>Toxicity:</u> Slight, decidedly less than nitroglycerin. Gelatinizing Action: | | | | |
| Impulse Energy | Flight on nitrocellulose. 82.2°C KI Test: Minutes 2 | | | | |

Nitroisobutylglycerol Trinitrate (NTBIN) Liquid

AMCP 706-177

Preparation:

A total of 675 gm 37% formalin is added to 150 gm nitromethane containing 2 gm potassium carbonate hemi-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 pressure and diluted, and this process repeated several times to remove formaldehyde. After the linal concentration the cooled mixture is filtered and the crystalline product recrystallized from alcohol and then several times from ether and dried.

The nitrated product is then obtained by nitrating 50 gm nitroisobutylglyce col with 300 gm mixed acid (60/38/2, sulfuric acid/nitric acid/water) below 15°C for 1.5 hours.

Origin:

This explosive (also called Trimethylolnitromethane Trinitrate, Nitroisobitanetriol Trinitrate, Nitroisobutylglycerin Trinitrate and incorrectly but widely used Nitroisobutylglycerol Trinitrate) was first described in 1912 by Hofwimmer (Z ges Schiess - Sprengstoffw 7, 43 (1912). Hofwimmer prepared the compound by the condensation of 3 moles of formaldehyde with 1 mole of nitromethane in the presence of potassium bicarbonate, the subsequent nitration of the product. The explosive can now be produced from coke, air, and natural gas.

References: 50

(a) H. A. Asronson, Study of Explosives Derived from Nitroparaffins, FATR No. 1125, 24 October 1941.

(b) M. Aubry, Mém poudr, 25, 197-204 (1932-33); CA 27, 4083 (1933).

(c) A. Stettbacher, Mitrocellulose 5, 159-62, 181-4, 203-6 (1934); CA 29, 1250 (1935).

(d) W. de C. Crator, U.S. Patent 2,112,749 (March 1938); CA 32, 3964 (1938).

(e) H. J. Hibshman, E. H. Pierson, and H. B. Hass, Ind Eng Chem <u>32</u>, 427-9 (1940); CA <u>34</u>, 3235 (1940).

(f) A. Stettbacher, Z ges Schless Sprengstoffv 37, 62-4 (1942); CA 38, 255 (1944).

⁵⁰See footnote 1, page 10.

Nitrostarch Demolition Explosive (NSX)

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| Composition: % | | Molecular Weight: | 325 |
|---------------------------------------------------|-----------|---------------------------------------|----------|
| Nitrostarch (12.50% N) | 49 | Oxygen Belance: | |
| Barium Nitrate | 40 | CO. % | -12 |
| Mononitronaphthalene | 7 | CO % | |
| Paranitroaniline | 3 | Density: gm/cc | |
| OIL | 1 | Melting Point: *C | |
| C/H Ratio | | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: | · | Boiling Point: "C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | 21 | Refractive Index, no | <u> </u> |
| Picatinny Arsenal Apparatus, in. | 8 | na | |
| Sample Wt, mg | | | |
| | | n | |
| Friction Pendulum Tast: | | Vacuum Stability Test: | |
| | es, snaps | cc/40 Hrs, at | |
| Fiber Shoe Unaffe | cted | 90°C | |
| Rifie Bullet Impact Test: 10 Trials | 8 Trisls* | - 190°C | 11+ |
| % | | 120°C | |
| Éxplosions 90 | ¥0 | 135*C | : |
| Partials Ö | 13 | 150°C | |
| Burned 0 | 0 | 200 Gram Bamb Sand Test: | |
| Unoffected 10 #Packed in paper | 87 | Sand, gm | 39.5 |
| Explation Temperature: "C | | Sansifivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | | Mercury Fulminate | 0.26 |
| 5 Decomposes 195 10 | | Leod Azide | •• |
| 15 | | Tetryl | |
| 20 | | Bailistic Morter, % TNT: (a) | 96 |
| | | Yrauzi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | 0.2 | Plate Dant Test: | <u> </u> |
| | | Method | |
| 100°C Heet Test: | | Condition | |
| % Loss, 1st 48 Hrs | 0.3 | Confined | |
| % Loss, 2nd 48 Hrs | 0.3 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisonce, % TNT | |
| Fianmability Index: | | - Detenation Rate: Confinement | |
| Hygroscopicity: % 30°C, 90% RH | 2.1 | - Condition Charge Diameter, in. | |
| Volatility: | | Density, gm/cc Rate, meters/second | |

| Nitrostarch | Demolition | Emlosive | (NSX) |
|---------------|-------------|------------|--------|
| NT CLOS CALCU | Demotration | DEDITIONIA | (IIII) |

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AMCP 706-177

| Fregmuntation Test: | Shapod Charge Effectiveness, TNT = 100: | |
|----------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, Ib | Glass Cones – Steel Cones Hole Volume Hole Depth | |
| Total No. of Fragments: For TNT | Calor: | |
| For Subject HE 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, lb | Principal Uses: Demolition, bursting charges, and priming compositions | |
| Total No. of Fregments: For TNT | Method of Looding: Hand tamped | |
| For Subject HE Fragmant Valocity: ft/sec | Leading Density: gm/cc Apparent 0.92 | |
| At 9 ft At 25½ ft | Storage: | |
| Density, gm/cc | Method Dry | |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) (1285 9 | |
| Air: Peak Pressure Impulse Energy | Compatibility Group Group I Exudation None | |
| Air, Cenfined: Impulse Under Water: | 120°C Heat Test: Selmon Pink 70 Red Fumes 255 | |
| Peak Pressure Impulse | Explodes 256 | |
| Energy Underground: Peak Pressure Impulse Energy | | |
| | | |

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Nitrostarch Demolition Explosive (NSX)

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Preparation: (b)

The nitration of starch proceeds with the formation of hexanitro starch according to the following equation:

$2C_6H_{10}O_5 + 6HNO_3 \rightarrow C_{12}H_{14}O_4(ONO_2)_6 + 6H_2O_5$

Tapicca starch is considered the best for nitration purposes, although other starches give fairly 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 nitrators containing mixed acid (62%-63% HNO₃ and 37%-38% H₂SO₄) is done slowly with constant agitation or the mixture. The heat evolved must be controlled by cooling coils. The mitrated starch is separated from the spent acid, washed with a large amount of water and centrifuged. Final drying is on trays heated to 35^{0} -40°C with air. This product is so sensitive even a static discharge might cause explosion.

Nitrostarch demolition explosives contain a high percentage of nitrostarch, an oxidizing agent, mineral oil, a stabilizer and/or other ingredients.

Origin:

Nitrostarch was first prepared in 1833 by Branconnot, who called it xyloidine (Ann chim phys [2] 52, 290 (1833)). T. J. Pelouze studied xyloidine further and reported its explosive properties (Compt rend 7, 713 (1838). 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. Federoff, <u>A Menual for Explosives Laboratories</u>, Vol I, Lefax Society, Inc., Philadelphia (1942).

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

| 1 | 5 | <u>4</u> | ĩ | <u>8</u> | 2 |
|------|-------------|----------|------|------------|------|
| 1611 | 782 2032 | 1034 | 1117 | 838 848 | 1269 |

51Sea footnote 1, page 10.

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Octo1, 70/30

| Composition: | | Molecular Weight: | 265 |
|--------------------------------------------------|------------|---------------------------------------|-------------|
| HMX | 70 | Oxygen Balance: CO ₂ % | 28 |
| INT | 30 | | -38 -7•5 |
| | 50 | Density: gm/cc Cas | it 1.80 |
| | | Molting Point: *C | |
| C/H Ratio | | Freezing Point: "C | |
| Impact Sonaltivity, 2 Kg Wt: | <u></u> | Boiling Point: "C | <u></u> |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | | Refructive Index, De | |
| Picatinny Arsenal Apparatus, in. | 18 | n2 | |
| Sample Wt, mg | 26 | n | |
| Friction Pendulum Test: | | Vocuum Stability Test: | |
| Steel Shoe | Unsflected | cc/40 Hrs, at | |
| Fiber Shoe | Unsifected | 90°C | |
| Rifle Builet Impact Test: Trials | | - 100°C | |
| 96 | | 120*C | 0.37 |
| 70 Explosions | | 135°C | |
| Partials | | 150°C | |
| Burned | | 200 Gram Bemb Sand Yest: | |
| Unaffected | | Sond, gm Exploratory | 58.4 |
| Explosion Temperature: | °C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | *** | Minimum Detonating Charge, gm | |
| 5 Flames erraticall | y 335 | Mercury Fulminate | |
| 10 | ~ ~~~ | Lood Azide | 0,30 |
| 15 | | Tetryi | |
| 20 | | Ballistic Morter, % TNT: | 115 |
| | | Treval Test, % TNT: | |
| 75°C International Heat Test: | | Plate Dant Yest: | |
| % Loss in 48 Hrs | | Method | |
| 100°C Host Test: | | Condition | |
| % Loss, 1st 48 Hrs | | Confined | |
| % Loss, 2nd 48 Hrs | | Density, gm/cc | |
| Explosion in 100 Hrs | | Brisonce, % TINT | |
| | | | <u></u> |
| Finnmability Index: | | Confinement | None |
| | | Condition | Cast |
| Hygroscopicity: % | | Charge Diameter, in. | 1.0 |
| | | Density, gm/cc | 1.80 |
| Valetility: | | Rate, metars/second | 8317 |
| | | · · · · · · · · · · · · · · · · · · · | |

AMCP 706-177

V

Octo1, 70/30

| Booster Sensitivity Test: | | Decomposition Equation: |
|--------------------------------------------|--------------|----------------------------------------------------------------------------------------|
| Condition | | Oxygen, atoms/sec |
| Tetryl, gm | | (Z/sec) |
| Wax, in. for 50% Detonation | | Heat, kilocalorie/mole |
| Wax, gm | | (ユH, kcal/mol) Temperature Range, °C |
| | | Phose |
| Density, gm/cc | | PROSE |
| Hent of: | 2722 | Armor Plate Impoct Test: |
| Combustion, cal/gm | 1074 | |
| Explosion, cal/gm | | 60 mm Mortar Projectile: |
| Gas Volume, cc/gm | 847 | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | | Aluminum Fineness |
| Fusion, cal/gm | | 500-16 General Purposa Bombs: |
| Specific Heat: cal/gm/°C | | |
| •••••••• | | Plate Thickness, inches |
| | | 1 |
| | | 112 |
| | | 114 |
| | | 14, |
| Burning Rate: | | |
| cm/sec | | Somb Drop Test: |
| Thermal Conductivity: | | |
| coi/sec/cm/°C | | 77, 2000-16 Semi-Armer-Plarcing Bomb vs Concrete: |
| Coefficient of Expension: | | Max Safe Drop, ft |
| Linear, %/*C | | 500-lb General Purpose Bomb vs. Concrete: |
| Volume, %/*C | | Height, ft |
| | | Trials |
| Hardness, Mohs' Scale: | | Unoffected |
| | | - Low Order |
| Young's Modulus: | | High Order |
| E', dynes/cm² | | righ broat |
| E, Ib/inch³ | | 1000-ib General Purpose Bomb vs Concrete: |
| Density, gm/cc | | |
| | 1510 | Height, ft |
| Compressive Strength: Ib/inch* | See below | Trials |
| | | Unaffected |
| Vapor Pressure: | | Low Order |
| C mm Mercury | | High Order |
| Compressive Strength: 1b/inch ² | * | |
| Average (10 tests) High | 1510 1740 | Ultimate Deformation: % |
| Low | 1330 | Average (10 tests) 2.26 High 2.58 Low 1.97 |

*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.

| Fregmentation Test: | Shaped Charge Effectiveness, TNT = 100: | |
|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|--------------|
| 90 mm HE, M71 Projectile, Lot WC-91: | Gloss Cones Steel Conss Hole Volume | |
| Density, gm/cc Charge Wt, lb | Hole Deptin | |
| Total No. of Fragmants: For TNT | Color: | Buff |
| For Subject HE | Principal Uses: HE projectile and bomb | filler |
| 3 inch HE, M42A1 Projectile, Let KC-5: | | |
| Density, gm/cc. Charge Wt, ib | · · · | |
| Terei Ne. of Fragments: For TNT | Instead of Loading: | CLat |
| For Subject HE | Leading Denuity: gm/cc | 1.80 |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft | Stereget: | |
| Density, gm/cc | Method | Dry |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distorice) | Class 9 |
| Air: Peak Pressure | Compatibility Group | Group I |
| Impulse | Exudation | |
| Energy | | |
| Air, Continud: Irapulse | <u>Mork to Produce Rupture:</u> ft-lb/inch ³ Average (10 tests) | * 1.55 |
| Under Weter: Peak Pressure | High Low | 1.87 1.10 |
| Impulse | Efflux Viscosity, Seybolt Seconds: | 5.9 |
| L-ergy | : | |
| Undergreand: Peak Pressure | | |
| impulse Energy | | |
| | "Test specimen 1/2" x 1/2" cylinder (mately 3 gm) pressed at 3 tons (6,00 total load or 30,000 psi with a 2 min time of duall. | 0 16) |

<u>Octol, 70/30</u>

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| | | One-Inch Column | | Two-Inch Column | |
|----------------------------------------|---------------------|-----------------|------------|-----------------|-----------|
| Explosive | Simulated Altitude, | Confined | Unconfined | Confined | Unconfine |
| | Fret | m/s | | 3/8 | E/ 8 |
| 70/30, RDX/INT; density, gm/cc 1.62 | Ground | 7900 | 8100 | 7660 | 8030 |
| density, gay ee not | 30,600 | 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; density, gm/cc 1.61 | Ground | 7960 | 7900(4) | 7870 | 7640(4) |
| density, gavee 1.01 | 30,000 | 8050 | 8060 | 7930 | 7710 |
| | 60,000 | 8020 | 7930 | 78-30 | 7650 |
| | 90,000 | 7950 | 8000 | 7940 | 7650 |
| Average | | 7995 | 7973 | 7908 | 7663 |

Effect of Altitude, Charge Diameter and Degree of Confinement on Detonation Velocity* (Reference b)

470/30 Octol 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 tetry booster was used to initiate each charge.

| | | 1 | Simulated A | ltitude, Fe | |
|----------------|--------------|---------------|-------------|----------------------|----------------------|
| Explosive | Charge Disme | Ground m/s | 30,000 | <u>60,000</u> ≊∕≋ | <u>90,000</u> ⊒∕∎ |
| 70/30, RDX/INT | 1 | 3415 | 3672 | 3666 | 3685 |
| | 2 | 4647 | 5192 | 6236 | 6011 |
| 70/30, HMC/INT | 1 | 3366 | 3680 | 4014 | 3617 |
| | . 5 | 4703 | 5464 | 6089 | 6111 |

Average Fragment Velocities at Various Altitudes* (g)

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

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| Tene | 17. | Strength:* |
|-------|-----|------------|
| 74119 | | |

| | lb/inch ² |
|-------------------|----------------------|
| Average (8 tests) | 169 |
| High | 204 |
| Lov | 128 |

*Test specimen as per Picstinny Arsensl sketch XL-076B, at 21°C.

Modulus of Elasticity:*

| Average (10 tests) | 1b/inch ² 73,200 |
|--------------------|--------------------------------|
| High | 79,300 |
| Low | 63,000 |

"Nest 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)

語言と

| Critical Pressure | 92,000 p#1* |
|-------------------|-------------|
| Density, gs/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 ML HE Projectile:

| ····· | ويتقارب والترجيح والترجيح | |
|-----------|---------------------------|-------------------------------------------|
| Weight Gi | oup, grains | No. of Fragments |
| 1/2 - | 2 | 1297 |
| 2 - | 5 | 665 |
| 5 - | 10 | 497 |
| 10 - | 25 | 661 |
| 25 - | 50 | 471 |
| 50 - | 75 | 247 |
| 75 - | 150 | 32? |
| 150 - | 750 | ji sa sa sa sa sa sa sa sa sa sa sa sa sa |
| 750 - | 2500 | 12 |
| Total Nuz | aber | 4467 |

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Octo1, 75/25

| Composition: % | | Malacular Weight: | 276 |
|---------------------------------------------------------------|------------|------------------------------------------------|-------------|
| HMX | 75 | Oxygen Bolonce: CO ₂ % | - 35 |
| INT | 25 | CO % | -6.3 |
| | | Density: gm/cc Cast | 1.81 |
| | | Making Point: *C | |
| C/H Ratio | | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | | Bailing Paint: "C | |
| Sample Wt 20 mg Picotinny Arsenal Apparatus, in. | 17 | Refrective Index, n ^D ₁₀ | |
| Sample Wt, mg | 25 | n _{as} | |
| · · · | - | n | |
| Friction Pandulum Test: | | Vocuum Stability Test: | |
| Steel Shoe | Unaffected | cc/40 His, at | |
| Fiber Shoe | Unaffected | 90°C | **** |
| Rifle Builet Import Yest: 10Triais \$ | | - 100°C | |
| 3/16" Steel | 1/8" A1 | 120*C | 0.39 |
| Explosions 70 | 70 | 135°C | |
| Partials | | 150°C | |
| Burned | | 200 Gram Bomb Sand Test: | |
| Unoffected 30 | 30 | Sond, gm Exploratory | 62.1 |
| Explosion Tamperature: | °C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | - | Mercury Fulminate | *** |
| 5 Flames erratically | 350 | Leod Azide | 0.30 |
| 10 15 | | Tetryl | **** |
| 20 | | Ballistia Mortur, % TNT: | 116 |
| 40 | | Tresul Test, % TNT: | |
| 75°C International Heat Test: | | Plate Dest Test: | |
| % Loss in 48 Hrs | | Method | |
| 100°C Heat Test: | | Condition | |
| % Loss, 1st 48 Hrs | | Confined | |
| % Loss, 2nd 48 Hrs | | Density, gm/cc | |
| Explosion in 100 Hrs | | Brisonce, % TNT | |
| | | - Detenstion Rote: | |
| Flammability Index: | | Confinement | None |
| Muunaanus laba - A | | Condition | Cast |
| Hygrascople Hys 96 | | Charge Diameter, in. | 1.0 |
| Veletility: | | Density, gm/cc | 1.81 |
| · •••••••• | | Rate, meters/second | 8643 |

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| Booster Sensitivity Test: Condition Tetryl, gm Wax, in. for 50% Detonation Wax, gm Density, gm/cc | | Decomposition Equation: Oxygen, atoms/sec (Z/sec) Heat, kilocalorie/mole (AH, kcal/mol) Temperature Range, °C Phase |
|------------------------------------------------------------------------------------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Neet ef: Combustion, cal/gm | 2676 | Armer Platu Impact Test: |
| · · · · | 1131 | |
| Explosion, cal/gm | 830 | 40 mm Morter Projectile: |
| Gas Volume, cc/gm | 0,00 | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | 29.4* | Aluminum Fineness |
| Fusion, cal/gm *Calculated for 76.9% HMX, 23.1% | | 500-ib Genzrei Parpose Bembe: |
| المين في الجاري منتخذ في المركبة المسلحين في منتخر الم المسلح الم المركبة المسلحين المركبة المسلحين ا | ** | 200-is Causiel Laibres course: |
| Specific riest: (al/gm/*℃ | 0.200 | Plate Thickness, inches |
| Specific Heat: cal/gm/*C -79°C -80° to +80°C | 0.240 | |
| 33° to 74° C | 0.245 | 1 |
| 90° to 150°C | 0.323 | 11/2 |
| **Determined for 76.9% HMX, 23.1% | INT. | 114 |
| | | 194 |
| Burning Rate: | | |
| cm/sec | | |
| | | Somb Drop Test: |
| Thermal Conductivity: | | |
| col/sec/cm/*C | | T7, 2000-16 Semi-Armer-Piercing Jemis vs Concrete: |
| | | Max Safe Drop, ft |
| Coefficient of Expension: | | |
| Linear, %/°C | | 500-16 General Purpose Bomb vs Cuncrote: |
| Volume, %/*C | | Halaba da |
| | | Height, ft |
| Herdness, Mohs' Scale: | | - Trials |
| | | Unaffected |
| Young's Modulus: | | Low Order |
| E', dynes/cm² | | High Order |
| E, lb/inch [*] | | |
| Density, gm/cc | | 1000-Ib General Purpose Namb ve Constrates |
| | | Height, ft |
| Compressive Strength: Ib/inch ^a | 1340 | Trials |
| | See below | Unaffected |
| Mune : Pressures | | Low Order |
| Vupsz Prossure: *C mm Mercury | | High Order |
| | *** | |
| Compressive Strength: 1b/inch ² | | 112 Advanta Defense d |
| Average (10 tests) High | 1340 1560 | Ultimate Deformation: 4 |
| row | 1040 | Average (10 tests) 2.43 High 2.89 Low 2.04 |

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

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AMCP 706-177

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Octol, 75/25

| Frugmantation 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 | |
| Totel No. of Fregments: For TNT For Subject HE | Celer: | Buff |
| 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib | Principel Uses: HE projectile and bomb | filler |
| Totel Ne. of Fragments: For TNT For Subject HE | Method of Loading: | Cast |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc | Loading Density: gm/cc Storage: Method | 1.81 Dry |
| Slast (Relative to TNT): Air: Peak Pressure Impulse | Hazard Class (Quantity-Distance) Compatibility Group Exudation | Class 9 Group I |
| Energy Air, Confined: Impulse Under Water: Peak Pressure Impulse Energy | Work to Produce Rupture: ft-1b/inch ³ Average (10 tests) High Low Efflux Viscosity, Saybolt Seconds: | * 1.31 1.57 1.07 9.0 |
| Underground: Peak 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. | 0 16) |

Octol, 75/25

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Fragment Velocity Test:

M26 Hand Grenade:

| Explosive | Average Fragment Velocity, ft/sec over lat 6 feet |
|----------------|------------------------------------------------------|
| Composition B | 4948 |
| 75/25 Cyclotol | 4908 |
| 75/25 Octal | 5124 |

Tensile Strength:*

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| ; | | | | lo/inch ² |
|---|---------|-----|--------|----------------------|
| | Average | (10 | tests) | 266 |
| l | High | • | | 330 |
| : | Low | | | 226 |

*Test specimen as per Picatinny Arsenal sketch XI-076B, at 21°C.

(#)

(a)

Modulus of Elasticity:*

| | 1b/inch ² |
|--------------------|----------------------|
| Average (10 tests) | 62,100 |
| High | 75,900 |
| Low | 45,200 |

*Test specimon $1/2" \ge 1/2"$ cylinder (approximately 3 gas) 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 : 76,000 pai* Density, gu/cc 1.80

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

Pit Frequentation Test:

105 mm ML HE Projectile:

| Weight Group, grains | No. of Fragments |
|----------------------|------------------|
| 1/2 - 2 | 1611 |
| 1 2 - 5 | ן דרי ן |
| 5 - 10 | 535 |
| 10 - 25 | 719 |
| 25 - 50 | 480 |
| 50 - 75 | 246 |
| 75 - 150 | .339 |
| 150 - 750 | 1 29 3 |
| 750 - 2500 | : 8 |
| Total Number | 5008 |

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Octol, 70/30; Octol, 75/25

Downloaded from http://www.everyspec.com

Preparation:

Water-wet HMX 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 Varied Explosive Systems and Condi-tions, National Northern Corporation Final Summary Report NNC-F-13, February 1958 (Contract DAT-19-020-501-ORD-(P)-58).

52See footnote 1, page 10.

PB-RDX

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| Composition: % | | Molecular Weight: | 245 |
|---------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| RDX | 90 | Oxygen Balance: | (0) |
| Polystyrene (unmodified) | 8.5 | CO, % CO % | -62 -18 |
| Dioctylphthalate | 1.5 | Density; gm/cc Unpressed Pellet pressed at 30,000 psi | 0.81 |
| | | 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 | Unpressed 28 15 20 | Bailing Paint: "C Refractive Index, n ^D n ^D n ^D n ^D | |
| Friction Pendulum Test: | | Vocuum Stability Test: | |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifle Bullet Impact Test: 10 Trials * | ······································ | | 0.41 |
| % | | 120°C 135°C | 0.41 |
| Explosions 10 | | 150°C | |
| Portials 90 | | | · · · · · · · · · · · · · · · · · · · |
| Burned O Unaffected O | | 200 Grem Bomb Sand Test: Sand, gm | |
| Explosion Temperature: "C Seconds, 0.1 (no cap used) 1 5 Saokes 275 10 15 20 | | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryi Bellistic Morter, % TNT: | |
| | | _ Trauzi 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 | 0.00 | Density, gm/cc Brisance, % TNT | |
| Explosion in 100 Hrs | None | | |
| Flammability Index: | · · · · · · · · · · · · · · · · · · · | Detonation Rate: Confinement | |
| Hygroscopicity: % | | Condition Charge Diameter, in. | |
| * Test procedure described in May 1956. | PATR No. 2247, | Density, gm/cc Rate, meters/second | |

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PB-RDX

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| Basster Sensitivity Test: | Decomposition Equation: |
|--------------------------------------------------------------------------|------------------------------------------------------|
| Condition | Oxygen, atoms/sec (Z/sec) |
| Tetryl, gm | Heat, kilocalorie/mole |
| Wax, in. for 50% Detanation | (ΔH, kcal/mol) |
| Wax, gm | Temperature Range, *C |
| Density, gm/cc | Phase |
| Heat si: | Armer Plets Impect Test: |
| Combustion, cal/gm 3027 | |
| Explotion, cal/gm 983 | 40 mm Martar Projactiles |
| Gas Valume, cc/gm | 50% inert, Velocity, ft/sec |
| Formation, cal/gm | Alumisum Fineness |
| Fusion, cal/gm | 500-S Ganarai Purpose Sombe: |
| Specific Heat: cal/gm/*C | |
| | Plate Thickness, Inches |
| | R . |
| | 11/4 |
| | 114 |
| | 1% |
| Buncing Rote: | |
| cm/sec | Some Dray Yests |
| Thermal Conductivity: | • |
| cal/sec/cm/*C | 57, 2000-16 Somel-Ancore Plancing 7 and ve Concessor |
| | Adam Cada Nama da |
| Caufficiant of Expansion: | Max Sate Drop, ft |
| Linear, %/*C | 560-16 General Parpose South vs Constants" |
| Volume, %/*C | Height, ft |
| | Trials |
| Hardness, Mahu' Scale: | Unaffected |
| | Low Order |
| Young's Modulus: See below | High Order |
| E', dynes/cm² | |
| E, Ib/inch [*] | 1000-% General Purpose Nemb vs Concrete: |
| Dansity, gm/ce | |
| | Height, ft |
| Compressive Strength: (b/inch [#] 2403 2149 Percent 8.9 13.1 | Triols |
| ۵٬۹۶۳ مې د د د د د د د د د د د د د د د د د د | Unaffected |
| Vuper Pressure: | Low Order |
| C mm Mercury | High Order |
| Young's Modulus: * (a) Temperature Ambient 95°C | |
| E, 1b/inch ² (avg of 5) 39,953 34,831 | |
| Density, gm/cc 1.60 1.57 | |
| | |

*Pellets (Lot CAC-595-55) 0.750 inch diameter by 0.750 inch long, pressed at 30,000 psi with 30-second dwell.

| Fregmentation Test: | Shaped Charge Effectivences, TNT = 100: | | | |
|---------------------------------------------------|-----------------------------------------|-------------------------------------------------------|--------------------------|--|
| 90 mm HE, M71 Projectile, Let WC-91: | | Glass Cones Ste | el Conas | |
| Density, gm/cc | Hole Volume | 1 | | |
| Charge Wt, Ib | Hole Depth | | | |
| Total No. of Fragmeniu: | Celor | | White | |
| For TNT | | | HIT AS | |
| For Subject HE | Princips! Uses: | High mechanica | 1 strength | |
| 3 inch HE, M42A7 Projectile, Let KC-3: | | explosive | - | |
| Density, gm/cc | | | | |
| Charge Wt, ib | | | | |
| Total No. of Fragments: | Method of Luce | ling: | Pressed | |
| For TNT | | - | | |
| for Subject HE | Leading Dansib | Loading Density (m/cc. Pressed, pai x 10 ³ | | |
| | 0 10 20 30 | | | |
| iragment Velocity: ft/sec At 9 ft At 25½ ft | 1.10 1.49 Sterege: | 1.59 1.62 | | |
| Density, gm/cc | arden and a | | | |
| Denary, Buy co | Method | | Dry | |
| liest (Relative to TNT); | Hazard Class (Quantity-Distance) Class | | Class 9 | |
| Air: Peak Pressure | Compatibility Group | | Group I | |
| Impulse | Exudation | • | None | |
| Energy | | | | |
| | | | | |
| Air, Cenfined: Impulse | Rockwell Re 1/2 inch di | rdness, "R" Scal. ameter Penetrato | e: (a) r, 60 Kg Load: | |
| Under Weter: | Pellet | Specific | | |
| Peak Pressure | <u>No.*</u> | Gravity | Hardness | |
| Impulse | 1 | 1.624 | 84 | |
| Energy | 2 3 4 5 6 | 1.623 | 90 | |
| | 2 | 1.611 1.600 | 84 80 | |
| Underground: | 5 | 1.590 | 75 | |
| Peak Pressure | | 1.571 | 73 | |
| Impulse | 7 | 1.548 | 62 | |
| Energy | 8 | 1.524 | 49 | |
| | *Pellets (Lo | t HOL-E-93) were and 3/4 inch high | 1-1/2 inches | |

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PB-RDX

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Sensitivity of PB-RDX and 98/2 RDX/Stearic Acid Pellets* to Initiation by Type II Special Blasting Capa (a)

| Dell et- | | | | ase of Ca | 0,450 | | |
|---------------------------------------------------------|-------|-------|-------|-----------|-------|-------|---------|
| Pellets | 0.250 | 0.,00 | 0.350 | 0.400 | 0.420 | 0.500 | 0.750 |
| PB-RDX with Pellet Density 1.55 gm/cc | - | | | | | | |
| No. of Triels | 1 | 8 | 5 | 6 | 2 | 1 | 1 |
| Average Depth of Plate Indentation, inches ** | 0.082 | 0.090 | 0.087 | 0.080 | 0.080 | | |
| No. of Failures | 0 | 1 | 3 | 4 | 1 | 1 | 1 |
| PB-RDX with Pellet Density 1.60 gm/cc | | | | | | | |
| No. of Trials | 3 | 8 | 9 | 4 | 3 | 5 | 2 |
| Average Depth of Place Indentation, inches ** | 0.090 | 0.089 | 0.087 | 0.084 | 0.087 | 0.075 | |
| No. of Failures | ٥ | 0 | 2 | 3 | 2 | 3 | 2 |
| 98/2 RDX/Stearie Acid With Pellet Density 1.53 gm/cc | _ | | | | | | |
| No. of Trials | 5 | 3 | 5 | 5 | 5 | 5 | 5 |
| Average Depth of Plate Indentation, inches ** | 0.109 | 0.096 | 0.095 | 0.092 | 0.097 | 0.087 | فليعيدن |
| No. of Failures | ٥ | 1 | 0 | 3 | 4 | 4 | 5 |

* Pellets 0.92 inch diameter, 0.375 inch height.

** Mild steel plate 5" x 5" x 1".

Performance of PB-RDX as Booster: (b, d)

Ton 2.75 inch HEAT ML Rocket Heads were unarflected in performance by storage at 71°C for 25 days. Thus, PB-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 M307A1 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.

Preparation:

The purchase description sheet for polystyrene-bonded RDX (X-PA-PD-1088, 25 October 1956) requires that the PB-RDX shall be a mixture of RDX, coated and surrounded by a homogeneous mixture of polystyrene and dioctylphthalate. 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:

| T | nrough U. S. Standard Sieve No. | Minimum % | Maximum K | 24 |
|---|------------------------------------|-------------|-----------|-----|
| | 6 | 100 | | |
| | 12 | <u>,</u> 60 | | ÷ |
| | 20 | | 2 | i i |
| | 35 | | <u> </u> | |

We 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 preparation gave a product which was uniform, free-flowing and dustless. In addition, PB-RDX granulated by the slurry method exhibited watisfactory drying, handling 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 dioctylphthalate were dissolved in 200 cc toluene in a lacquer dissolver. Steam was introduced into the jacket until the temperature reached 65°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_2O (ratio 1:10) were added to the granulator. 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 charging 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 intraduced 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° 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 Taboratory of the University of California (Contract W-7405-Eng 36 with U. S. Atomic Energy

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PB-RDX

PB-RDX

Commission, Report No. IA-1448). The specific formulation of 90/8.5/1.5 RDX/polystyrene/ dioctylphthalate was subsequently standardized by Los Alamos. This explosive, originally designated PBX, has been redesignated PB-RDX. The detailed requirements for the present polystyrene-bonded RDX(PB-RDX) are given in purchase description X-PA-PD-1088, 25 October 1956.

References: 53

(a) P. J. Zlotucha, T. W. Stevens and C. E. Jacobson, <u>Characteristics of Polystyrene-Bonded RDX(PB-RDX)</u>, PATR No. 2497, April 1958.

(b) A. J. Pascazio, The Suitability of a Bare PEX Booster Fellet in the 2.75 Inch MI HEAT Rocket Head, PATR No. 2271, November 1955.

(c) J. L. Vermillion and R. C. Dubberly, <u>Plastic-Bonded RDX</u>, <u>Its Preparation by the Slurry</u> <u>Method</u>, Holston Defense Corporation, Control No. 20-T-16 Series A (PAC 1081), 5 March 1953.

(d) C. J. Eichinger, <u>Report on Cartridge HEAT 57 mm M307A1 (Mod)</u> with <u>Modified Copper</u> Liner, Aberdeen Proving Ground, Development and Proof Services, First Report on OC Project TA3-5204, October 1957.

³See footnote 1, page 10.

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Pentserythritol Tripttrate (PETRIN)

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AMCF 786-177

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| Composition: % | Melesuier Weight: (C5H9N3010) | en | | | |
|--------------------------------------------------|---------------------------------------|-------------|--|--|--|
| c 22.1 | Oxygen Balance: | | | | |
| CH_ONO_ | | -2% 3 | | | |
| и 3.3 носи2 - си20но | | | | | |
| N 15-5 - | Density: gm/cc | 1.54 | | | |
| 0 59.1 CE20H02 | Moliting Point: *C | 26 to 28 | | | |
| C/H Ratio 0.141 | Freezing Point: "C | | | | |
| Import Sensitivity, 2 Kg We: | Builing Point: "C 4 mm Hg Decomposes | 130 | | | |
| Bureou of Mines Apparatus, cm Sample Wt 20 mg | Refrective Index, no | | | | |
| Picatinny Arsenal Apparatus, in. 5 to 10 | n2 | | | | |
| Sample Wr, mg 38 | | | | | |
| | n | | | | |
| Friction Pendulum Yest: | Vacuum Stability Test: | | | | |
| Steel Shoe | cc/40 Hrs, at | | | | |
| Fiber Shoe | 90°C | | | | |
| Rifie Bullet Import Text: Trigis | 100°C | 2.54 to 5.6 | | | |
| | 120°C | | | | |
| Sectoria Sectoria | 135°C | | | | |
| Partials | 150°C | | | | |
| Burned | | | | | |
| Unoffected | 200 Green Bond Sead Test: Sand, am | | | | |
| Unotrected | sana, gm | | | | |
| Explosion Temperature: *C | Sensitivity to Initiation: | | | | |
| Seconds, 0.1 (no cop used) | Minimum D**/nating Charge, gm | | | | |
| 1 | Mercury Fulminate | | | | |
| 5 | Louid Aside | | | | |
| 10 | Tetryi | | | | |
| 15 | | | | | |
| 20 | Bellistic Merter, % TNT: | | | | |
| 75°C International Heat Test: | Trouni Teet, % TNT: | | | | |
| % Loss in 48 hirs | Plate Dant Test: Method | | | | |
| | Constition | | | | |
| 100°C Huat Test: | Confined | | | | |
| % Loss, 1st 48 Hrs | | | | | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | | | | |
| Explosion in 100 Hrs | Brisonce, % TNT | | | | |
| Riemanahilia, Indus. | Ditension Rate: | | | | |
| Planmability Index: | Confinement | | | | |
| Hugensenteiten W | Condition | | | | |
| Hygroscopicity: % | Charge Diameter, in. | | | | |
| M-Indillan. | Density, gm/cc | | | | |
| Velatility: | Rate, maters/second | | | | |

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Pentaerythritol Trinitrate (PETRIN)

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| Fragmentation Test: | Shaped Charge Effectiveness, TNT == 109: |
|-------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: | Glass Cones Steel Cones |
| Density, gm/cc | Hale Volume |
| Charge Wt, Ib | Hole Depth |
| Total No. of Fragments: | Celer: White |
| For TNT | will Ce |
| For Subject HE | Principal Uses: Explosive, properlant or |
| 3 inch HE, M42A1 Projectile, Let KC-3: | igniter ingredient |
| Density, gm/cc | |
| Charge Wt, ib | |
| Total Na. of Fragments: | Method of Londing: |
| For TNT | |
| For Subject HE | Louding Density: gm/cc |
| | |
| Frequent Velocity: ft/sec At 9 ft | |
| At 25% ft | Storage: |
| Density, gm/cc | Advature d |
| | Method Dry |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) |
| ب عنگ | Compatibility Group |
| Peak Pressure | |
| Impulse | Erudation None |
| Energy | |
| Air, Confined: impulse | PETRIN esters are listed in reference (b) and most of these esters have been shown to have explosive properties. |
| Under Weter: Peak Préssure Impulse Ene.gy | An infrared spectrophotometric procedure was developed for the detarmination 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 |
| Underground: Freak Pressure Impulse Energy Absolute Vircosity, poises: Temp, 17°C 14.3 23°C 4.3 28°C 3.0 38°C 1.2 | a volumetric flask. The acetone content of the PETRIN solution is determined by its infra- red absorption at 5.52,4 in a 0.5 mm cell. A double been method is used with a reference cell containing chloroform and acetone-free PETRIN. The quantity of the latter must be corefully ad used to give a good balance be- tween the test sample and reference cells for the strong PETRIN peak at 6.02,4 maximum. Heat of- |
| | Explosion, cal/bn 1204 |

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Pentserythritol Trinitrate (PETRIN)

AMCP 706-177

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| Freparation: | | | | • | |
|--------------------------------------|----------------|---------------------|--------------------------------------------------------------------|---|---------------|
| | | ₩230 ¹ 1 | | | |
| с(сн ₂ он) _ь + | 3HNO 3 | | onch ⁵ c(ch ⁵ to ²) ³ | + | 3H20 |
| pentserythritol | nitric scid | sulfuric acid | pentsery thritol trinitrate | | weter |
| N# 136 | MF 63 | MN 98 | MV 271 | • | N # 18 |

Downlo

The earliest procedure used for the manufacture of PETRIN was that developed at Alleghany Ballistics Laboratory. In this process, called the "A process," 80% HNO₃ and the solid pertaerythritol were charged to the reactor and 80% H₂SO₄ was added slowly at 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 pertacrythritol. The cake was dissolved in actions and neutralized in solution with ammonium carbonate, after which the PETN was precipitated by the addition of water. After filtration, the PETNIN was recovered from the filtrate by stripping off the solveit 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 period, water was added to dilute the mixed acid and the batch was extracted in situ with mathylene chloride. The organic layer was separated, neutralized with equeous 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 assentially the simultaneous synthesis and extraction of PETRIN from the reaction mixture. Nathylene chloride approximately equal to the total usight 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 golvent is removed and replaced by fresh solvent one or more times. The combined extracts are neutralized and concentrated. Because of their initially relatively large volume, PETM must be removed by filtration from the concentrated PETRINE solution before the final solvent is stripped. Yields by this process have been 60% to 65%.

Origin:

The nitration products of pentwerythritol or its derivatives containing not more than three NO₂ groups were patented for use as explosives, propellants or ignition materials in 1936 (German Patents 635.432 and 635.433; CA <u>31</u>, 1212 (1937)).

A process in which pentaerythritol monoscetate was converted to pentaerythritol trinitrate momoscetate, which was then saponified under carefully controlled conditions to PETRIE, was reported in 1954 (N. S. Marans, D. E. Elrick and R. F. Preckel, J Am Chem Soc <u>76</u>, 1304). PETRIE was also prepared by the mitration of pentaerythritol with a mixture of BOS HNO₃ and \pm 05 H₂SO₄ in 1955 (A. T. Camp, N. S. Marans, D. E. Elrick and R. F. Preckel, J Am Chem Soc <u>17</u>, 751).

Pentaerythritol Trinitrate (PETRIN)

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References:54

(a) Rohm and Haas Company, Redstone Arsenal Division, <u>Process</u> for the <u>Manufacture of</u> <u>Pentserythritol Trinitrate Monoscrylate and Petrin Acrylate Propellants</u>, 12 March 1956.

(b) E. Berlow, R. H. Barth and J. E. Snow, The Pentaerythritols, ACS Monograph No. 136, p. 65, Reinhold Publishing Coryoration, New York, 1958.

(c) R. H. Pierson, <u>An Infrared Spectrophotometric Method for Determination of Acetone</u> <u>Content of Pentaerythritoltrinitrate</u>, U.S. Naval Ordnauce Test Station Report NOTS 1877, MAVORD Report No. 5649, 3 February 1958.

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C. Jarvalle

54See footnote 1, page 10.

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<u>Pentaerythritol Trinitroacrylate (PETRIN Acrylate)</u> (Trinitroxypentaerythritol Acrylate)

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AMCP 706-177

| Composition: % | Monomer) (C8H11N3011) | 325 | | |
|-----------------------------------------------------------------------------------------------------------------|----------------------------------------|------------|--|--|
| c 29.5 | Oxygen Belence: | | | |
| H 3.4 CH2ONO2 | CO, % CO % | -54 -12 | | |
| CH2 - CH-CO2CH2C-CH20N02 | Density: gm/cc | | | |
| 0 51.2 CH_ONO2 | Making Point: °C 78 t | o 79 | | |
| C/H Ratio 0.239 | Freezing Point: *C | | | |
| Impact Sansitivity, 2 Kg Wt: | Beiling Point: 'C | | | |
| Bureau of Mines Apparatus, cm | | | | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. | Refrective Index, no | | | |
| Sample Wt, mg | n | | | |
| والمراجع المراجع المراجع المراجع والمراجع والمراجع المراجع المراجع والمراجع والمراجع والمراجع والمراجع والمراجع | n | | | |
| Friction Pendulum Test: | Vocuum Stability Test: | | | |
| Steel Shoe | cc/40 Hrs, at | | | |
| Fiber Shoe | 90°C | | | |
| Rifle Bullet Import Teet: Trials | 100°C | | | |
| %a | 12010 | | | |
| Explosions | 135°C 150°C | | | |
| Portiols | | | | |
| Burned | 200 Grem Bemb Send Test: | | | |
| Unaffected | Sand, gm | | | |
| Explasion Temperature: *C | Sensitivity to Initiation: | | | |
| Suconds, 0.1 (na cop used) | Minimum Detonating Charge, gm | | | |
| 1 | Mercury Fulminate | | | |
| 5 | Loud Azide | | | |
| 10 | Tetnyi | | | |
| 15 20 | Ballia is Merter, % TNT: | | | |
| 4V | Treat Ter, % TNT: | | | |
| 75°C International Hast Test: | Fiete Deet Test: | _ | | |
| % Loss in 48 Hrs | Method | | | |
| 100°C Heut Tast: | Condition | | | |
| 96 Loss, 1st 48 Hvs | Confined | | | |
| 70 CO22, 127 40 MH2 96 Cu22, 2nd 48 MH2 | Density, gm/cc Brisance, % TNT | | | |
| Explasion in 100 Hrs | | | | |
| | Datenaties Rate: | | | |
| Flemmability Index: | Confinement | | | |
| | Condition | | | |
| Hygroscopicity: % N12 | Charge Diameter, in. Density, gm/cc | | | |
| | | | | |
| Velatility: | Rate, meters/second | , | | |

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Pentaerythritol Trinitroscrylate (PETRIN Acrylate)

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| Fregmentation Test: | Shaped Charge Effectivenest. TNT = 100: | |
|----------------------------------------|------------------------------------------------|---|
| 90 mm HE, M71 Projectile, Lot WC-91; | Glass Cones Steel Cones | |
| Density, gm/cc | Hoie Volume | |
| Charge Wt, Ib | Hole Depti: | |
| Total No. of Fragments: For TNT | Color: White | 1 |
| | | |
| For Subject HE | Principal Uses: Ingredient of composite | |
| 3 inch HE, M42Aî Projectile, Let KC-S: | rocket propellants | |
| Density, gm/cc | | |
| Charge Wt, Ib * | | |
| Yotal No. of Fregments; | Method of Losding: | |
| For TNT | marines of receival: | |
| For Subject HE | | |
| | Looding Density: gm/cc | |
| Fregment Velocity: ft/sec | | |
| At 9 ft At 25% ft | Storege: | |
| Density, gm/cc | | |
| | Method Dry at temperatures below melting point | |
| Blast (Rolative to TNT): | Hazard Class (Quantity-Distance) | |
| Air: | Compatibility Group | |
| Peck Pressure | Companying Group | |
| Impulse | Exudation None | |
| Energy | | |
| | Veet of | |
| Air, Confined: | Heat of: | |
| Impulse | Combustion, cal/gm 2923 | |
| Undar Water: Peak Pressure | Explosion, cal/gm 791 | |
| Impulse | 1 | |
| Energy | | |
| Underground: Peak Pressure | | |
| Impulse | | |
| Energy | | |
| | | 1 |
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Pentagrythritol Trinitroscrylate (PETRIN Acrylate)

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AMCP 706-177

| Preparation: | | (a) | | | | |
|---------------------------------------------------------------------------|-------|--------------------------------|---------------------|------|-----------------------|--|
| Hoch2c(ch2NO3)3 | + | CH2 = CHCOCL | + | с6н | 5N(CH3)2 | |
| pentmerythritol trinitrate (PETRIN) MW 271 Q | | ecrylyl chloride MW 90.5 | | an | ethyl iline 121 | |
| (୦ ₂ ೫୦୦ ମ ₂) ₃ ୦୦ ମ ² ୦୦୦ ପ | 1 = 0 | 1H2 + C6H51 | N(CH ₃) | 2HCI | (| |
| pentaerythritol trini acrylate (PETRIN acr | | | thyle | | | |

acrylate (PETRIN acrylate) MW 325

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The original synthesis for FETRIN acrylate employed trifluoroacetic anhydride and glacial acrylic sold 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° to 15° C. Following a period of one houw, the batch was drowned in water, precipitating the PETRIN acrylate. This solid was separate by filtration, dissolved in chloroform, and neutralized in solution with sodium bicarbonate. The product was then crystal-lized during a period of 16 hours at 0° 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 98%) 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 trifluoroscetic anhydride, a new process, based on dimethylaniline and acrylyl chloride, was considered. This process is currently under development in the Rohm and Hass 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 oxidizer increases both the impulse and burning rate.

A composition which presently appears most promising is as follows:

| | Composi | tion NM |
|-----------------------------------|---------|----------------------------|
| PETRIN acrylate (> 97% purity), % | | (binder) |
| Triethylene glycol trinitrate, 🐔 | 11.8 (| (plasticizer) |
| Glycol discrylate, % | 2.9 (| (crosslinker) |
| Ammonium perchlorate, % | 51.0 | (oxidizer) |
| Hydroquinone, 🖇 | 0.014 (| (polymerization inhibitor) |

Measured specific impulse 238 lb-sec/lb, at density of 1.3.

Reference:55

(a) Rohm and Haas Company, Redatone Arsens] Division, Process for the Manufacture of Pentaerythritol Tetranitrate Monoscrylate and Petrin Acrylate Propellants, 12 March 1956.

SiSee footnote 1, page 10.

Pentolite, 50/50; 10/90

| | | | | 50/50; 10/90 | | |
|--------------------------------------------------|--------------------------------|-----------------|-----------------------|----------------------------------------|---------------------|---------------------|
| Composition: | | ···· | | Molecular Weights | <u>50/50</u> 265 | <u>10/90</u> 234 |
| % | 50 | | 10 | Oxygen Balance: | | |
| PETN | 50 | | 10 | CO, % | -42 - 5 | -68 -21 |
| INT | 50 | | 90 | Density: gm/cc | 1.65 | 1.60 |
| | | | | Matting Point: *C | <u></u> | 76 |
| C/H Ratio | | | | Freazing Points *C | | |
| Import Sonaitivi | ty, 2 Kg Wt: nes Apparatus, | 50/ cm 3 | <u>50 10/90</u> 65 | Bolüng Point: *C | | |
| Sample Wt | 20 mg | | | Refrective Index, ng | - | |
| Picatinny Ars Sample Wt, | enal Apparatus ma | i, in. 12 15 | | កដ្ឋារ 🖓 🗸 | | |
| | | | | n <mark>p</mark> | | |
| Friction Pendulu | im Test: | | | Vacuum Stability Test: | 50/50 | 10/90 |
| Steel Shoe | | | Unaffected | cc/40 Hrs, at | | |
| Fiber Shoe | | | Unaffected | 90°C | 3.0 | 3.0 |
| Rifie Bullet Imp | ect Test: 25 T | rials, 50/ | 50 | 120°C | 11+ | 11+ |
| | | % | | 135°C | | ** |
| Explosions | | 72 | | 150°C | | •• |
| Partials | | 20 | | | | |
| Burned Unaffected | | 0 8 | | 200 Grace Bosel Send Test: Sond, gm | 55.6 | 49.5 |
| Undriected | | | | | | 49.5 |
| Explesion Tomp | | •C, 50 | /50 | Sansitivity to Initiation: | | <u>50/50</u> |
| Seconds, U.I | (no cap used) | 290 | | Minimum Detenating Ch | iarge, gm | 0.19* |
| 5 | Decomposes | 266 220 | | Mercury Fulminate | | 0,13* |
| 10 | | 204 | | | | - |
| 15 | | 197 | | *Alternative initiati | ng charges | · |
| 20 | | >190 | | Ballistic Mortur, % TNT: | (a) | 126 |
| | | | | Trauzi Yest, % TN'i: | (b) | 122 |
| 75°C Internation % Loss in 48 | | | | Plate Dent Test: Method | (c) | В |
| 14010 11 | | | 50/50 | Condition | | Cast |
| 100°C Heat Tet | | • | <u>50/50</u> | Confined | | No |
| % Loss, 1st | | | 0.0 | Density, gm/cc | | 1.66 |
| % Low, 2nd Explosion in 1 | | | 0.2 | Brisance, % TNT | | 121 |
| | | | None | Detenation Rate: | | |
| Flammability in | dex: Will no | t contin | ue to burn | Confinement | | None |
| | | 50/50 | 10/00 | Condition | | Cast |
| Hygroscopicity: 30°C, 90% | % RH | 50/50 None | 10/99 None | Charge Diameter, in. | | 1.0 |
| | | | | Density, gm/cc | | 1.66 |
| Veletility: | | | | Rate, meters/second | | 7465 |

Pentolite, 50/50; 10/90

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AMCP 706-177

| Boester Sensitivity Test: (d) | 50/50 | Decomposition Equation: | |
|------------------------------------------------|-----------------------------------------------|-------------------------------------|-----------------|
| Condition Pressed | Cast | Oxygen, otoms/sec (Z/sec) | |
| Tetryl, gm 100 | 100 | Heat, kilocalorie/mole | |
| Wax, in. for 50% Detonation 2.36 | 2.08 | (SH, kcal/moi) | |
| Wax, gm | A _ | Temperature Range, *C | |
| Density, gm/cc 1,60 | 1.65 | Pinase | |
| Heat ef: Combustion, cal/gm | ·· <u>····</u> ······························ | Armer Platy Impact Teet: | 50/50 |
| Explosion, cal/gm | 1220 | 60 mm Morter Projectile: | |
| Gas Valume, cc/gm | | 50% inert, Velocity, ft/sec | 170 |
| Formation, cel/2m | | Aluminum Fineness | |
| Fusion, cal/gm | | | |
| | ······· | 500-lb General Purpose Bombe: | |
| Specific Heet: coi/gm/*C | | Plate Thickness, inches | |
| | | | |
| | | 11/4 | |
| | | 14 | |
| | | | |
| Burning Rete: | | 134 | , |
| cm/sec | | Somb Drop Test; | |
| Thermel Conductivity: | | | |
| col/sec/cm/°C | | T7, 2000-1b Semi-Armur-Pierciag Ben | ib vs Concreta: |
| Coefficient of Expension: | | Max Safe Drop, ft | |
| Linear, %/°C | | 500-lþ General Purpese Bamb vs Con | crete: |
| Volume, %/°C | | Height, ft | |
| | | Trials | |
| Hardness, Mohs' Scale: | | Unaffected | |
| Manual Adadation | · · · · · · · · · | Low Order | |
| Young's Modulus: | | High Order | |
| E', dynes/cm² | | | |
| E, ib/inch ² | | 1000-it General Purpose Bomb vs Con | krete: |
| Density, gm/cc | | | |
| Compressive Strength: Ib/inch ² 200 | 0-2200 | Height, ft | |
| Density, gm/ce | 1.68 | Triols | · |
| | | Unaffected | |
| Vepor Pressure: *C mm Mercury | | Low Order | |
| *C mm Mercury | | High Order | |
| | | ······ | |
| | | | |
| | | | |

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Pentolite, 50/50; 10/90

21

| Fragmontation Test: | 50/50 | Shaped Charge Effectiveness, TNT == 100: 50/50 10/90 50/50 25/75 |
|----------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: | | Gloss Cones(f) Steel Cones (g) |
| Density, gm/cc | 1.65 | Hole Volume 157 105 149 119 |
| Charge Wt, Ib | 2.: (| Hole Depth 116 116 131 119 |
| Total No. of Fregments: | | Ceier: Yellow-white |
| For TNT | 703 | |
| For Subject HE | 968 | Principal Uses: Shaped charges, bursting |
| 3 inch HE, M42A1 Projectile, Let KC-5: | | charges, demolition blocks |
| Density, gm/cc | 1.65 | |
| Charge Wt, Ib | 0.872 | |
| Total No. of Fragments: | | Method of Londing: Cast |
| For TNT For Subject HE | 514 650 | |
| · · · · · · · · · · · · · · · · · · · | | Looding Density: gm/cc 50/50 10/90 |
| Frequent Velocity: ft/suc | - 0 | 1.65 1.60 |
| At 9 ft At 25½ ft | 2810 2580 | Sterage: |
| Density, gm/cc | 1.66 | Method Dry |
| Blast (Relative to TNT): | (•) | Hazard Class (Quantity-Distance) Class 9 |
| Ai+: | | Compatibility Group Group I |
| Peak Pressure | 105 | |
| impulse | 107 | Exudation |
| Energy | •• | Compatibility with Mateles |
| Air, Confined: | | Compatibility with Metala: |
| Impulse | | Dry: Copper, brass, aluminum, magnesium, magnesium-aluminum alloy, mild steel conted with acid-proof black paint, and mild steel |
| Under Water: Peak Pressure | | plated with copper, cadmium or nickel are not affected. Zinc plated steel is only slightly |
| Impulse | | affected. |
| Energy | | Wet: Stainless steel, eluminum and mild steel costed with acid-proof black point are |
| Underground: Peak Pressure | | not affected. Copper, brass, magnesium, mag- nesium-aluminum alloy, mild steel and mild |
| Impulse | | steel plated with copper, cadmium, zinc or nickel are slightly affected. |
| Energy | | Effect of Temperature on (h) |
| Eutectic Temperature, ^O C: | 76 | Rate of Detonetion: 50/50 |
| gm PETI/100 gm TNT 76°C | 13.0 | 16 hrs at, °C -54 21 Density, gm/cc 1.67 1.66 Rate, m/sec 7470 7440 |
| 95°č | 25.3 | |

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Pentolite, 50/50; 10/90

AMCP 706-177

Preparation:

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Pentolite is manufactured by either the slurry method or coprecipitation of PETN and TNT. In the slurry method PETN, in water, is stirred and heated above 80° C. TNT is added and when molten, it coats the particles of PETN. The slurry is cooled with rapid stirring and the separated granules are collected on a filter and dried below 75°C.

In coprecipitation, PETN and TNT are dissolved separately in acetome. 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:

Standardized during World War II, with the 50-50 PEIN/INT mixture being the more important for bursting charges and booster-surround charges.

References: 56

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

(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 Maxo 10,303, 15 June 1949.

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

(f) Eastern Laboratory, du Pont, Investigation of Cavity Effect, Sec III, Variation of Cavity Effect with Explosive Composition, NDRC Contract W672-ORD-5723.

(g) Eastern Laboratory, du Pont, <u>Investigation</u> of <u>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, <u>Detonation Rates of the More Important Military Explo-</u> sives at Several Different Temperatures, PATR No. 2383, November 1936.

(i) Also see the following Picatinny Arsenal Technical Report on Pentolite:

| <u>0</u> | <u>1</u> | 2 | 3 | <u>4</u> | 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 |

⁵⁶See footnote 1, page 10.

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PETN (Pentaerythritol Tetranitrate)

| Composition: % | | Meleculer Weight: (C5H8N4012) | 316 |
|---------------------------------------------------------------|-----------------|-----------------------------------------|-----------|
| C 19.0 0NO2 | | Oxygen Balance: | |
| | | CO, % CO % | -10 15 |
| | | | |
| N 17.7 02NO-CH2-C-CH | 2 0.002 | Density: gm/cc Crystal | 1.77 |
| ο εο.8 ^{CH} 2 | | Making Point: *C | 141 |
| C/H Rotio 0.134 ONO2 | | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 17 | Boiling Point: *C | |
| Sample Wt 20 mg | • | Refrective Index, np | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 6 16 | nas | |
| aampie vri, mg | | n _{be} | |
| Friction Pondulum Test: | | Vacuum Stubility Tast: | |
| Steel Shoe C | Trackles | cc/40 Hrs, at | |
| řiber Shoe U | Jnaffecteä | 90°C | |
| Rifle Buliet Impact Test: 5 Trials * | | - 100°C | 0.5 |
| 96 | | 120*C | 11+ |
| Explosions 100 | | 135°C | |
| Partials 0 | | 150*C | |
| Burned O | | 200 Gram Bomb Sand Test: | |
| Unoffected 0 #4.80% molature in samples | | Sand, gm | 62.7 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) 272 | | Minimum Detonating Charge, gm | |
| 1 244 5 Decomposes 225 | | Mercury Fulminate | 0.17* |
| 5 Decomposes 225 | | Lead Azide | 0.03* |
| 10 211 | | Terryl *Alternative initiating charg | |
| 20 | | Ballistic Mortur, % TNT: (a) | 145 |
| | ···· | Treuzi Test, % TNT: (b) | 173 |
| 75°C International Heat Test: % Loss in 48 Hrs | 0.02 | Fiete Dent Test: (c) | ····· |
| -0 6038 (11 90 F115 | 0.02 | Method | A |
| 100°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 |
| Rissenskiller fodere 11633 och er bil | | - Detenction Rate: | |
| Flammability Index: Will not contin | ue to burn | Confinement | None |
| Hygrescepicity: % 30°C, 90% RL | 0.0 | Condition | Pressed |
| | | Charge Diameter, in. | 1.00 |
| Velatility: | 0.0 | Density, gm/cc | 1.70 |
| • | | Rate, meters/second | 8300 |

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PETN (Pentaerythritol Tetranitrate)

AMCP 706-177

| Beaster Sensitivity Test: Condition | (c) Pressed | Decomposition Equation: (e) (e) (f) Oxygen, atoms/sec $10^{19.8}$ $10^{20.6}$ $10^{23.1}$ |
|--------------------------------------------|----------------------------------------|----------------------------------------------------------------------------------------------|
| Tetryi, gm | 5 | (Z/sec) Heat, kilocalorie/mole 47.0 50.9 52.3 |
| Wax, in. for 50% Detonation | | (SH, kcal/mol) |
| Wax, gm | 3 | Temperature Range, *C 161-233 108-120 137-157 |
| Density, gm/cc | 1.6 | Phose Liquid Solid At melt- ing point |
| Heat of: Combustion, cai/gm | 1960 | Armer Piete Impect Test: |
| Explosion, cal/gm | 1385 | |
| Gas Volume, cc/gm | 790 | 60 mm Morter Projectile: 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | 383 | Aluminum Fineness |
| Fusion, cal/gm | | |
| · | | 500-ib General Purpose Bombs: |
| Specific Heat: cal/gm/*C | (d) | |
| Room Temperature | 0.26 | Plate Thickness, inches |
| KOOM TEMPETE CUTA | V. EU | 1 |
| | | 11/4 |
| | | 11/4 |
| | | 134 |
| Burning Kata; | | |
| cm/sec | | Somb Droy Test: |
| Thurmal Conductivity: cal/sec/um/*C | ************************************** | T7; 2060-16 Somi-Armor-Plancing Bomb vs Concrute: |
| Coefficient of Expension: | | Max Safe Drop, ft |
| Linear, %/*C | | 300-lb General Purpose Bomb vs Concrete: |
| Volume, %/°C | | Height, ft |
| Hariness, Mohs' Scala: | 1.9 | Triois Unaffected |
| | | Low Order |
| Young's Modulus: | | High Order |
| E', dynes/cm² | | |
| E, ib/inch ^z | | 1000-lb General Purpose Bamb vs Concrete: |
| Density, gm/cc | | |
| | | |
| Compressive Strength; ib/inch ² | | Trials |
| | | Unaffected |
| Vapar Pressure: | | Low Order |
| *C mm Mercury | | High Order |
| | | |
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PETN (Pentaerythritol Tetranitrate)

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| Fregmentation Test: | Shaped Charge Effectiveness, TNT == 1 | 00: | |
|----------------------------------------|------------------------------------------------------|---------------------------|--|
| 90 mm HE, M71 Projectile, Lat WC-91: | Glass Cones Steel (| Cones | |
| Density, gm/cc | Hole Volume | | |
| Charge Wt, Ib | Hole Deptri | | |
| Total No. of Fragments; | Caler: | | |
| For TNT | | White | |
| For Subject HE | | | |
| 3 inch HE, M42A1 Projectile, Lot KG-5; | Principal Uses: Class A - Detonating fuse an | d boosters | |
| Density, gm/cc | Class R - Priming composition | | |
| Charge Wt, Ib | | | |
| | | | |
| Total No. of Fragments: | Method of Loading: | | |
| For TNT | | | |
| For Subject HE | | | |
| | Loading Density: gm/cc psi x 3 5 10 20 5 | 10 ⁻³ 10 40 | |
| Fragment Velocity: ft/sec | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | 3 1.74 | |
| At 9 ft At 25½ ft | Storage: | | |
| Density, gm/cc | | •• | |
| | Method | Wet | |
| Blest (Relative to TNT): | Hozard Class (Quantity-Distance) | Class 9 | |
| Air: | Compatibility Group | Group M (wet) | |
| Peak Pressure | | | |
| Impulse | Exudation | None | |
| Energy | ····· | | |
| Air, Confined: | Bulk Modulus at Room | (i) | |
| Impulse | Temperature (25°-30°C): | | |
| | $Dynes/cm^2 \times 10^{-10}$ | 4.60 | |
| Under Water: Peak Pressure | Density, gu/cc | 1.77 | |
| Impulse | | | |
| Energy | | | |
| Underground: | | | |
| Peak Pressure | | | |
| Impulse | | | |
| Energy | | | |
| | | | |
| | | | |
| | | | |
| | 1 | | |
| | | | |

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PETN (Pentaerythritol Tetranitrate)

Compatibility with Metals:

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Dry: Copper, brass, aluminum, magnesium, magnesium-aluminum alloy, stainless steel, mild steel, mild steel coated with scid-proof black paint and mild steel plated with copper, cadmium, nickel or zinc are not affected.

Wet: Stainless steel is unaffected and aluminum only vary slightly so after prolonged storage. Copper, brass, magnesium, magnesium-aluminum 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 PETN to electrostatic discharge, joules; Through 100 Mesh: (g)

*

| Unconfined | 0.06 |
|------------|------|
| Confined | 0.21 |

Solubility, grams of PEIN per 100 grams (\$) of: (h)

| Trichlorethylene or Alcohol | | Ac | Acetone | | nzene | Toluene | |
|--------------------------------|----------------------------------|---------------------------|----------------------------------|---------------------|----------------------------------|-----------------------------------------|---------------------------------------------------------------|
| °c | Z | <u>°c</u> | Ł | °c | ž | °c | ž |
| 0 20 40 60 | 0.070 0.195 0.415 1.205 | 0 02 03 00 00 | 14.37 24.95 30.56 42.68 | 0 20 40 80 | 0.150 0.450 1.160 7.900 | 0 20 40 60 80 100 112 | 0.150 0.430 0.620 2.490 5.850 15.920 30.900 |

| Methyl acetate | | Ether | | acetute | | Cl.lorobenzene | |
|---------------------------|----------------------|-----------------|-------------------------|----------------------------|-----------------------------------|----------------------|-----------------------------------|
| <u>°c</u> | s. | °C | z | °c | <u>e</u> z | °C | ž |
| 20 30 40 50 | 13 17 22 31 | 0 20 34•7 | 0.200 0.340 0.450 | 20 30 40 50 60 | 1.5 4.1 7.6 11.2 14.2 | 20 30 40 50 | 0.35 2.8 6.1 9.2 12.2 |
| <u>Ethylenedichloride</u> | | Metha | nol | Tetraci | loroethane | Car tetrac | bon hloride |
| <u>°c</u> | <u>5</u> | ಿಂ | ž | <u>°C</u> | ž | °c | é |
| 10 30 50 | 0.9 1.5 2.6 | 20 40 60 | 0.46 1.15 2.6 | 20 30 40 | 0.18 0.27 0.40 | 20 30 40 | 0.096 0.103 0.118 |

50

0.58

PERN (Pentaerythritol Tetranitrate)

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125

| Isopropanol | | Isobu | Isobutanol | | Chloroform | | TNT | |
|-------------|----------------|------------|--------------|-------------|------------|-----------|--------------|--|
| °c | ž | <u>°c</u> | ź | °c | ٤ | <u>°c</u> | ź | |
| 15 | 0.02 | 20 | 0.27 | 20 | 0.09 | 80 | 19.3 | |
| 20 | 0.04 | 30 | 0.31 | | • | 85 | 25.0 | |
| 30 | 0.15 | 40 | 0.39 | | | 90 | 32.1 | |
| 40 | 0.36 | 50 | 0.52 | | | 95 | | |
| 50 | 0.46 | • | | | | 100 | 39.5 48.6 | |
| | | | | | | 105 | 58.2 | |
| | Eutetic of the | evatem PET | N-TNT is abo | out 13% PET | IN . | 110 | 70.0 | |
| | and 87% TNT at | 76°C. | °c. | | | | 87.8 | |
| | | | | | | 120 | 115 | |

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Proparation:

(Nitroglycerin and Nitroglycerin Explosives, Nacum)

 $8HCHO + CH_3CHO + CB(OH)_2 \longrightarrow 2C(CH_2OH)_1 + CB(HCOO)_2 C(CH_2OH)_1 + 4HNO_3 \longrightarrow C(CH_2OHO_2)_1 + 4H_2O$

1. In this preparation 1940 gm of iormaldehyde and 600 gm of acetaldehyde 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 oxalic acid, filtered off, and the water removed under reduced pressure. On cooling the mother liquor about 1200 gm crude pentaery-thritol, melting point $235^{\circ}-240^{\circ}C$ are obtained. Purification is readily effected by stirring with a little alcohol, filtering and recrystallization from water.

2. To 400 cc of strong white nitric acid, are added 100 gm of pentacrythritol (through 50 mesh), at 5° C or below, under good agitation. After addition is complete stirring, at 5° 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:

PETH was known as an explosive in 1894 when it was proposed as an addition to smokeless powders to raise their flammability and case of combustion (Gorman Patent <u>81,664</u> (1894). Modern methods of preparation are described by Vignon and Gerin (Compt rend <u>133</u>, 590 (1901) ant German Patent 265,025 (1912) and A. Stettbacher (Z ges Schiess - Sprengstoffw <u>11</u>, 122, 182 (1916) and <u>24</u>, 259 (1929)). PETN was not used on a practical basis until after World War I.

Destruction by Chemical Decomposition:

PETM is decomposed by dissolving in 8 times its weight of technical grade acetone and burning the solution in a shallow container. If preferred, warm the acetone solution to 40° C, stir and add 7 parts by weight, to each part of PETM, of a solution of 1 part sodium sulfide $(Na_2S\cdot9H_2C)$ in 2 parts water heated to 80°C. The aqueous solution should be added at such a rate that the acetone solution does not boil. After mixing is complete continue stirring for one-half hour.

PEIN (Pentaerythritol Tetranitrate)

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References:57

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

(b) Ph. Naoum, Z ges Chiess - Sprengstoffy, pp. 181, 229, 267 (27 June 1932).

(c) D. P. MacDougall, Methods of Physical festing, 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 Utsh, <u>Ind & Eng Chem</u>, (June 1956), pp. 1090-1095.

(f) A. J. B. Robertson, "The Thermal Decomposition of Pentaerythritol Tetranitrate, Nitroglycerin, 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. Lept of Int, Bureau of Mines, RI 3852, 1946.

(h) Various sources in the open literature.

(1) W. S. Cramer, <u>Bulk Compressibility Inte on Several High Explosives</u>, NAVORD Report No. 4380, 15 September 1956.

(j) Also see the following Picatinny Arsenal Technical Reports on PEIN:

| <u>o</u> | <u>1</u> | <u>2</u> | 3 | <u>4</u> | 2 | <u>6</u> | I | <u>8</u> | 2 |
|-------------------------------------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------|-----------------------------|----------------------------------------------|----------------------------------------------------------------------|-----------------------------------------------------------|--------------------------------------------------------------------|--------------------------------------|
| 750 1170 1260 1390 1320 1360 1380 1390 1430 1450 1570 | 1041 1311 1381 1451 1561 1611 1651 | 772 922 1182 1292 1212 1262 1342 1352 1352 1372 1452 | 843 863 1063 1133 1253 1343 1493 1533 | 904 1274 1284 1414 | 1305 1325 1445 1705 1885 2125 | 1246 1276 1316 1376 1446 1456 1466 1556 1796 | 407 527 857 1247 1517 1617 1737 1797 | 318 839 1238 1318 1388 1568 1598 1838 2178 | 1379 1429 1489 1559 2179 |

⁵⁷See footnote 1, page 10.

Picramide (TNA) (2,4,6-Trinitroaniline)

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| Composition: | Molecular Weighe: $(C_6H_1N_4O_6)$ | 228 |
|---------------------------------------------------|------------------------------------|-------------|
| % NH2 | Oxygon Balance, | 1 |
| H 1.8 0 ₂ N 1 NO ₂ | CO2 % | -56 -14 |
| $H = 1.8 \qquad O_2 N \qquad NO_2$ N 24.5 | Density: gm/cc Crystal | 1.76 |
| 0 42.2 NO ₂ | Melting Point: "C | 189 to 190 |
| C/H Ratio 0.500 | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: | Beiling Point: "C Decomposes bef | ore boiling |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | Ratractive Index, nº | point |
| Picatinny Arsenal Apparatus, in. 23 | | |
| Sample Wt, rag 20 | nä | |
| ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ | n ^D | |
| Friction Pendulum Test: | Vocuum Stability Test: | |
| Steel Shoe | cc/40 Hrs, at | |
| Fiber Shoe | 90°C | |
| Rifle Bullet Impact Test: Trigis | 100°C | 0.9 |
| 96 | 120*C | |
| та та та та та та та та та та та та та т | 135*C | |
| Partials | 150°C | |
| Burned | 200 Gran Bomb Sand Tast: | |
| Unaffected | Sand, gm | 48.1 |
| Explosion Temperature: "C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | |
| 1 | Mercury Fulminate | **** |
| 5 | Leod Azide | 0.30 |
| 10 | Tetryl | |
| 15 20 | Ballissie Morter, % TNT: | 100 |
| | Travel Tost, % TNT: | 107 |
| 75°C International Heat Test: % Loss in 48 Hrs | Plate Dent Tout: | |
| | Method | |
| 100'C Heet Test: | Condition | |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | |
| Explosion in 100 Hrs | Brisonce, % TNT | |
| | Detenction Rate: | |
| Flammability Index: | Confinement | None |
| | Condition | Pressed |
| Hygroscopicity: % | Charge Diameter, in. | 0.5 |
| | Density, gm/cc | 1.72 |
| Voletility: | Rate, nieters/second | 7300 |

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Picramide (TNA) (2,4,6-Trinitroeniline)

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| Fragmentation Vest: | Shaped 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: | Celer: Yalloy |
| For TNT | |
| For Subject HE | Principal Uses: High temperature heat |
| 3 inch HE, M42A1 Projectile, Lot KC-5: | resistent explosive |
| Density, gm/cc | |
| Charge Wt, Ib | |
| Total No. of Fragments: | Method of Looding: Dress |
| For TNT | Method of Looding: Press |
| for Subject HE | |
| | Leading Density: gm/cc At 50,000 psi 1.72 |
| Fregmont Velocity: ft/sec At 9 ft | At 50,000 psi 1.72 |
| At 25½ ↔ | Storage: |
| Density, gm/cc | Method Dry |
| liast (Relative to TNT): | Hazard Class (Quantity-Distance) Class |
| Air: | Compatibility Group Group |
| Peak Pressure | |
| Impulse | Exudation None |
| Energy | |
| Air, Confixed: | Solubility: |
| Impulse | Insoluble in water, slightly soluble in |
| Under Water: | alcohol and ether. Soluble in hot glacial |
| Peok Pressure | acetic acid, hot ethyl acetate and in benze and acetone. |
| Impulse | |
| Energy | Heat of: |
| Underground: | Combustion, cal/gm (a) 2962 |
| Peak Pressure | Explosion, cal/gm 564 Formation, cal/gm (a) 131 |
| impulse | |
| Energy | |
| | |
| | |
| | |

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Picramide (TNA) (2,4,6-Trinitroaniline)

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Preparation:

Five grams of picryl chloride were dissolved in 180 milliliters of absolute methanol. The solution was then saturated with anhydrous, gaseous ammonia. The time required was approximately \mathcal{V} minutes. The amino derivative precipitated in 78% yield (3.6 gm) melting at 190°C (literature MP 189°C).

Origin:

Picramide (2, 4, 6-trinitrosniline) was first prepared in 1854 by Pisani who treated picryl chloride with ammonium carbonate (CR 39, 853). The use of picramide, as a brisant explosive, was patended by Chemische Pabrik Grieshein 26 May 1894 (German Patent 84,628). Meisenheimer and Patzig reacted trinitrobinzene 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 acetic acid or concentrated H_2SO_4 at about 5°C with concentrated RNO₃ (Ber 41, 3091 (1908)). Holleman gives details of the prep ation from p-nitrosniline and from acctanilide (Rec trav chim 49, 112 (1930)).

Reference:58

(a) William H. Rinkenbach, "The Neets of Combustion and Formation of Aromatic Nitro Compounds," J An Chem Soc <u>52</u>, 116 (1930).

58See footnote 1, page 10.

Picratol, 52/48

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| Somposition: % | | Molecular Weight: | 236 |
|---------------------------------------------------------------|------------|--------------------------------------|-------------------------|
| zo Explosive D 52 | | Oxygen Belance: | |
| . , | | CO, % CO % | -63 -19 |
| TNT 48 | | | |
| | | Density: gm/cc Caat | 1.62 |
| | | Maiting Point: °C | |
| C/H Ratio | | Freezing Point: *C | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 100+ | Boiling Point: "C | |
| Sample Wt 20 mg | | Refrective Index, NW | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 17 19 | , un | |
| www.riprite.trtc, ring | | n | |
| Friction Pendulum Teut: | | Vecuum Stability Test: | ····· |
| Steel Shoe | Unsifected | cc/40 Hrs, -: | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifly Builot Impact Test: Trials | | - 100.0 | 0.37 |
| • | | 120°C | 0.68 |
| Explosions 0 | | 135°C | |
| Partials 0 | | 150*C | 0.7 |
| Burned 40 | | 200 Grant Hemb Send Test: | |
| Unaffected 60 | | Sand, gm | 45.0 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 9.1 (no cap used) 456 | | Minimum Detonating Charge, gm | |
| 1 354 | | Mercury Fulminate | |
| 5 Decomposes 285 | | Leod Azide | 0.20 |
| 10 265 | | Tetryl | 0.05 |
| 15 260 | | Ballinia Adarbas Di Thitte () | |
| 20 255 | | Bellistic Menter, % TNT: (a) | 100 |
| 75°C Infurnational Heat Test: | | Treusl Test, % TNT: | م مربقه میشوند. م |
| % Loss in 48 Hrs | 0.0 | Plote Dent Test: (b) Method | a |
| | | Condition | , B Cast |
| 100°C Heat Test: | | Contined | No |
| % Loss, 1st 48 Hrs | 0.0 | | ло 1.63 |
| % Loss, 2nd 48 Hrs | 0-05 | Density, gr./cc | 1.03 |
| Explosion in 100 Hrs | None | Brisonce, % TNT | 100 |
| Slemmebillty Index: | | - Detoschen Rete: (b) Confinement | None |
| | | - Condition | Cast |
| Hygroscopicity: % 30°C, 90% RH | 0.02 | Charge Diameter, In. | 1.0 |
| | · | | 1.63 |
| Veletility: | | Density, gm/cc | |
| | | Rate, meters/second | 6976 |

Picratol, 52/48

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| Frugmantation Yest: | | Shaped Charge Effectiveness, THT = 10 | 101 |
|--------------------------------------|--------------|---------------------------------------------------------------------|----------------|
| 90 mm HE, M71 Frojectile, Let WC- | 91: | Gluss Cones Store C | ones |
| Density, gm/cc | 1.61 | Hole Volume | |
| Charge Wt, Ib | 2.075 | Hole Depth | |
| Total No. of Fragments: | | Celer: Bro | |
| For TNT | 703 | Bro | wn-yellow |
| For Subject HE | 769 | Principal Uses: AP, SAP projectile | and bombs |
| 3 inch IIX, MAZAT Projectile, Lot KC | -5: | | |
| Dansity, gm/cc | 1.61 | | |
| Charge Wt, ib | 0.850 | | |
| Yotel No. of Fragments: | | | |
| For TNT | 514 | Method of Losding: | Cast |
| For Subject HE | 487 | | |
| | | Louding Density: gm/cc | 1.62 |
| Fregmont Velocity: 11/sec | | • | |
| At 9 ft At 25½ ft | 2590 2320 | Storage: | |
| Density, gm/cc | 1.62 | | |
| | | Method | Dary |
| Slast (Relative to TNT); | ······ | Hazard Closs (Quantity-Distance) | Class 9 |
| Air: | | Compatibility Group | Group I |
| Peak Pressure | 100 | | |
| Impulse | 100 | Exudotion | None at 65°C |
| Energy | | Duran and he are a | |
| Air, Confinad: | | Preparation: | ĺ |
| Inpulse | | Picretol 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 | iform in com- |
| Pesk Pressure | | position. This slurry is cooled | |
| Impulse | | and poured into the appropriate component. | ammunition |
| Energy | | | |
| Underground: | | <u>Origin:</u> | |
| Peak Pressure | | Developed during World War II | as an insensi- |
| impulse | | tive, melt-loaded AP bomb and pr | |
| Energy | | Booster Sensitivity Test: | (c) |
| Bomb Drop Test: | | Condition | Cest |
| T7, 2000-1b Semi-Armor-Piero | of ng | Tetryl, gm Wax, in. for 50% Detonation | 100 1.00 |
| Bomb vs Concrete: | v = + 18 | Density, gn/cc | 1.63 |
| Max Safe Drop, ft 10,00 | 00-12,000 | | - |

Picratol, 52/48

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References: 59

(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, Part III - Miscellanzous 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, <u>A Consideratic</u> of RDX/Wax Mixtures as a Substitute for <u>Tetryl in Boosters</u>, NOL Memo 10,303, 15 June 1949.

(d) R. W. Drske, Fragment Velocity and Panel Penetration of Several Explosives in Simulated Shells, OSRD Report No. 5622, 2 January 1946.

(e) Also see the following Picatinny Arsenal Technical Reports on Picratol:

| <u>o</u> | 2 | 6 | ĩ | <u>8</u> | 2 |
|----------|------|------------------------|--------------|----------|------|
| 1470 | 1885 | 1466 . 1796 1956 | 1737 1797 | 1838 | 1729 |

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⁵⁹See footnote 1, page 10.

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Picric Acid

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| Composition: | 1 | Molecular Weight: (C ₆ H | 3 ^N 3 ^O 7) | 229 |
|---------------------------------------------------|----------|--------------------------------------|----------------------------------|----------|
| он с 31.5 | | Oxygen Balance: CO ₂ % | | -45 |
| H 1.3 02N | - NO2 | CO % | | -3-5 |
| N 18.3 | Sec. 1 | Density: gm/cc | Crystal | 1.76 |
| 48.9 | ı | Melting Point: *C | | 122 |
| C/H Ratio 0.656 | | Freezing Point: "C | | |
| Impact Sensitivity, 2 Kg We: | 85 | Boiling Point: *C | | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | 05 | Refrective Index, no | | |
| Picatinny Arsenal Apparatus, in. | 13 | n <mark>0</mark> | | |
| Sample Wt, mg | 17 | n ₂₀ | | |
| Friction Pendulum Test: | <u> </u> | Vacuum Stability Test: | | |
| Steel Shoe | | cc/40 Hrs, at | | |
| Fiber Shoe | | 90°C | | |
| Rifle Bullet Impact Test: Tria!s | | - 100°C | | 0.2 |
| - | | 120°C | | 0.5 |
| Skeletions 96 | | 135°C | | |
| Partials 60 | | 150°C | • | |
| Burned 40 | | 200 Grem Bemb Send Test | 1 | |
| Unaffected 0 | | Sand, gm | | 48.5 |
| Explosion Temperature: *C | | Sonsitivity to Initiation: | | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating C | horge, gm | |
|) 5 Decomposes 320 | | Mercury Fulminate | | 0.26* |
| 10 | | Leod Azide | | 0.24* |
| 15 | | #Alternative initiati | ng charges. | |
| 20 | | Ballistic Mortur, % TNT: | (a) | 112 |
| | | Trauzi Test, % TNT: | (b) | 101 |
| 75°C International Heat Test: % Loss in 48 Hrs | 0.05 | Plate Dart Test: | (c) | |
| | 0.09 | Method | | A |
| 100 C Heat Tast: | | Condition | | Pressed |
| % Loss, 1st 48 Hrs | 0.03 | Confined | | No |
| % Loss, 2nd 48 Hrs | 0.09 | Density, gm/cc | | 1.50 |
| Explosion in 100 Hrs | None | Brisonce, % TNT | | 107 |
| lemmebility Index: | | - Detenation Rate: | (d) | |
| | | Confinement | | confined |
| Hygroscopicity: % 30°C, 90% RH | 0.04 | Condition | Pressed | Cast |
| | <u> </u> | Charge Diameter, in. | 1.0 | 1.25 |
| Volatility: | | Density, gm/cc | 1.64 | 1.71 |
| • · | | Rote, meters/second | 5270 | 7350 |

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Picric Acid

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| Booster Sensitivity Test: | (Pressed | c) Cast | Decomposition Equation: |
|---------------------------------------------------------------|---------------------|---------------------------|---------------------------------------------------|
| Condition | | | Oxygen, atoms/sec (Z/sec) |
| Tetryl, gm | 10 | 5 | Heat, kilocalorie/mole |
| Wax, in. for 50% Detanation | | | (Sit, kcal/mol) |
| Wax, griv | 2 | 0 | Temperature Runge, *C |
| Density, gm/cc | 1.6 | 1.7 | Phase |
| Heat of: | | | Armar Plate Impact Test: |
| Combustion, cal/gm | | 672 | |
| Explosion, cal/gm | | 000 | 60 mm Morter Projectile: |
| Gas Volume, cc/gm | | 675 | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm 👘 🦿 | | 248 | Aluminura Fineness |
| Fusion, cal/gm (e) | | 0.4 | |
| Temperature, °C | | 122 | 500-16 General Purpose Bombs: |
| Sp.cifie Heet: cai/gm/*C (e) 0 0 | | | Plate Thickness, inches |
| 0 | | .235 | |
| 30 60 | | .258 | 1 |
| | | .310 | 114 |
| 120 | | • 337 | 114 |
| | | | 134 |
| Burning Rate: | | | |
| cm/sec · | | | Somb Drop Test: |
| Thermal Conductivity: (1) col/sec/cm/°C, Density, gu/cc | 6.24 x | : 10 ⁻⁴ 406 | 77, 2000-lb Somi-Armor-Piercing Somb v: Coustate: |
| | | | Max Safe Drop, ft |
| Coofficient of Expansion: Linear, %/*C | | | 500-là Ganeral Purpose Bomb ve Concrete: |
| Volume, %/°C | | | Height, ft |
| | سري فكل مرداد فلنهج | | Tricia |
| Hardness, Mohs' Scale: | 2 | .1 | Unaffected |
| | | | |
| Young's Modulze: | | | Low Order |
| E', dynes/cm² | | | High Order _ |
| E, Ib/inch ^a | | | 1000-ib General Purpose, Bomb ve Concrete: |
| Density, gm/cc | | | |
| | | | Height, ft |
| Compressive Strength; Ib/inch ^a | | | Trials |
| · | | | Unoffected |
| Vapor Pressura; | | | Low Order |
| *C mm Mercu | ry . | | High Order |
| 195 2 | | | |
| 255 50 | | | |
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| Fragmantation Test: | Skeped Charge Eff. ctiveness, TNT \simeq 100: | | | | |
|-----------------------------------------|-----------------------------------------------------------|--------------------|--|--|--|
| 90 mm HE, M71 Projectile, Let WC-91: | Gioss Cones Stee | i Cones | | | |
| Density, gm/cc | Hole Volume | | | | |
| Charge Wt, Ib | Hole Depth | | | | |
| Total No. of Fragmants: | Coier: | Yellow | | | |
| For TNT | | | | | |
| For Subject HE | Principel Uses: Formerly projec | | | | |
| 3 inch HE, M42A'I Projectile, Let KC-5: | now explosive admixture; an manufacture of Explosive D | | | | |
| Density, gm/cc | | | | | |
| Charge Wt, Ib | 3 | | | | |
| Total No. of Fragments: | Method of Loading: | Pressed | | | |
| For TNT | | | | | |
| For Subject HE | | | | | |
| | | 1×10^3 | | | |
| Fregment Valocity: It/sec | 3 5 10 12 1.40 1.50 1.57 1.59 | 15 20 1.61 1.64 | | | |
| At 9 ft | | 1.01 1.04 | | | |
| At 251/2 ft | Storages | | | | |
| Density, gm/cc | Method | Dry | | | |
| Blast (Relative to THT): | Hazard Class (Quantity-Distance) | Class 9 | | | |
| Alr: | Compatibility Group | Group I | | | |
| Peak Pressure | | | | | |
| Impulse | Exudation | None | | | |
| Energy | | | | | |
| Air, Confined: Impulse | | | | | |
| Under Water: Poak Pressure | | | | | |
| impulse | | | | | |
| Energy | | | | | |
| Underground: Peak Pressura | | | | | |
| Impulse | | | | | |
| Energy | | | | | |
| | j. | | | | |
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Picrie Acid

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Solubility: grams per 100 grams (%) of: (g)

| Wat | ter | Al | coho | Ber | izene | To | luene | Eth | er |
|---------------------------------------------|---------------------------------------------|---------------|--------------------|--------------|-------------------------|----------|------------|------------|------------|
| °c | ź | °c | k | °c | ž | °C | ¥ | °c | ž |
| 0 22 20 20 20 20 20 20 | 0.85 1.17 1.88 2.98 4.53 7.1 | င် လ ၀ | 4.5 6.9 12.0 | လင်လ စင်ဖ | ~2 9.6 27.5 59 | 20 60 | ~13 ~30 | 20 34•7 | ~3 3.96 |

| Chlore | oform | Ethyl (| acetate | | bon chloride | . <u>Py</u> z | idine . | Acet | tone |
|---------------------|----------------------------|----------------------|----------------------|-------------------|---------------------|--------------------------|------------------|----------------------|--------------------------|
| °c | é | °c | Ł | °c | ź | <u>°c</u> | ž | <u>°c</u> | 乏 |
| 20 60 | ~2 ~5 | 20 30 40 50 | 42 58 58 69 | 20 60 | ~0.07 ~0.4 | 10 30 50 | 24 37.5 58 | 20 30 40 50 | 125 137 164 208 |
| Me | Methanol Isopropyl alcohol | | hol | Propenol-1 | | Carbon disulfide | | | |
| <u>•</u> . | · £ | °c | | ٤ | <u>°C</u> | ź | °c | z | |
| 0 20 40 50 | 14 19 31 41 | 10 30 50 | | 6.4 9.8 5.5 | 0 20 29 50 | 2.4 3.3 5.4 7.4 | 20 30 | 0.12 0.10 | |

Preparation: (Summary Paport of NDRC, Div 8, Vol 1)

| с6н6 + нв(1ю3)2 | с _{6^н5^н5^н8^{но}3} + ело3 | (1) |
|----------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|------|
| С6H5HgN03 * N2O4 | с ₆₄₅ но + не(no3)2 | (2) |
| C6H5NO + 2NO | с _{б^н5^N2^{NO}3} | (34) |
| с6H5N2N03 + H20 | c ₆ H ₅ OH + N ₂ + HNO ₃ | (30) |
| с6450к + ню3 <u>No</u> 5 | O ⁵ NC ⁴ ^f OH + H ⁵ O | (3e) |
| C6H5NO HNO3 cxidation and rearrangement | o2nc6H ^t on | (4) |
| 0 ⁵ ис ⁶ он + нио ³ <u>ио⁵</u> | (02N)5сензон + н ⁵ 0 | (5) |
| (0 ² N) ⁵ С ⁶ H ³ OH + НЮ ³ <u>№</u> ⁵ | (02N)3C6H2OH + H2O | (6) |

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Picric Acid

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The two variables of greatest importance 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 rapidly, 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 oxynitratic. The oxynitration solution must be fortified frequently, or, preferably, continuously with ni ric 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 benzene is probably the most critical variable affecting the proportion of neutral nitro-compounds to nitrophenols and amounts of colored by-products. Saturation of the exynitration solution with benzene is undesirable and thus in batch processes slow benzene 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 fairly wide range. Concentrations of 0.37 to 0.5 mole of mercuric nitrate per liter of oxynitration solution have been found to give satisfactory results in most cases.

A continuous process, known us the continuous solution process, works on the following cycle. The oxynitration solution is saturated with benzene by vigorous agitation with excess benzene at room temperature, the saturated solution is separated from excess benzene and circulated through a heated coil; it is then cooled to room temperature and agitated 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 per hour is representative perforance. The dinitrophenol is, of course, nitrated to picric acid.

Origin:

Picric Acid was first prepared in 1771 by Woulff who found the reaction of nitric acid and indigo yielded a dya. Housmann isolated Picric Acid in 1778 and studied it further (Journal de physique 32, 165 (1788)). The preparation was studied by many chemists but in 1841 Laurent established its identity (Ann chim phys HII, 3, 221 (1841)). It was used as a yellow dya until Turpin, in 1885, proposed Picric Acid as a bursting charge for high explosive shell (French Patent 167,512). The British adopted Picric Acid as a military explosive in 1882 under the name of lyddite and other nations soon began to use it as the first meltloaded high explosive. Mixtures of other explosives and Picric Acid were developed until it was gradually replaced by TNT about 1900. Today Picric Acid is used for the manufacture of Explosive D.

Destruction by Chemical Decomposition:

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 ($Na_2S'9H_2O$) in 200 parts of water. Some hydrogen sulfide and ammonia are evolved.

Picrie Acid

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References: 60

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(a) L. C. Smith and E. G. Eyster, Phyrical 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) G. H. Messerly, The Rate of Detonation of Various Explosive Compounds, OSRD Report No. 1219, 22 February 1943.

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

(e) International Critical Tables.

(f) E. Hutchinson, The Thermal Sensitiveness of Explosives. The Thermal Conductivity Explosive Materials, AC Report No. 2861, First Report, August 1942.

(g) Values taken from various sources in the open literature.

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

| <u>1</u> | 2 | 3 | <u>4</u> | 2 | <u>6</u> | ĩ | <u>8</u> | 2 |
|----------|------------------------------------|------|-------------------|-------------------|-----------------------------------------|--------------|----------|------|
| 1651 | 132 582 1172 1352 1372 | 1383 | 694 764 874 | 65 425 1585 | 266 556 926 976 986 1446 | 1347 1557 | 1118 | 1549 |

⁶⁰See footnots 1, page 10.

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| Composition: | | Molecular Weight: | | 310 |
|---------------------------------------------------------------|---------|----------------------------|-----------|-------------|
| 20 | | Oxygen Balance: | | |
| PETN | 81 | CO ₂ % | | -74 |
| Gulf Crown E Oil | 19 | CO % | | - 31 |
| | | Density: gm/cc Hand | tamped | 1.35 |
| | | Melting Point: "C | | |
| C/H Ratio | | Freezing Point: *C | | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | | Beiling Point: "C | | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. | 11 | Refractive Index, nin | | |
| Sample Wt, mg | 27 | n <mark>n</mark> | | |
| | | n | | |
| Friction Pendulum Test: | ffected | Vocuum Stability Test: | | |
| | | cc/40 Hrs, at 90°C | | |
| Fiber Shoe Una: | ffected | - 100°C | | 0.48 |
| Rifie Bullet Import Test: Trials | | 120°C 16 ho | | 11+ |
| % | | 135°C | | |
| Explosions 0 | | 150°C | | |
| Portials O | | 150°C | | |
| Burned O | | 200 Grein Beinb Sand Test | : | |
| Unaffected 1.00 | | Sand, gm | | 41.6 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | | |
| Seconds, 0.1 (no cop used) | | Minimum Detonating C | harge, gm | |
| 1 5 Decomposes* | | Mercury Fulminate | | 0.20* |
| 10 | | Leod Azide | | 0.20* |
| 15 | | #Alternative initiati | ng charge | t# · |
| 20 | | Ballistic Marter, % TMT: | | |
| *No value obtained. | | Trauzi Test, % TNT: | | |
| 75°C Internetional Heat Test: % Loss in 48 Hrs | | Plate Dant Test: | (a) | |
| | | Method | | В |
| 100°C Hest Tast: | | Condition | | Hand tamped |
| % Loss, 1st 48 Hrs | 0.17 | Confined | | No |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/cc | | 1.33 |
| Explosion in 100 Hrs | None | Brisonce, % TNT | | 76 |
| Fienmebility Index: | | Detenation Rate: | | N |
| Tremmerinty intest | | Confinement | | None |
| Hyprocenticity: % 30°C, 90% RH | 0.02 | Condition | | Hand tamped |
| | 0.02 | Charge Diameter, in. | | 1.0 |
| 'dietility: | | Density, gm/cc | | 1.37 |
| * ********* * * | | Rate, meters/second | | 7075 |

調整

PIPE AMCP 706-177 Sheped Charge Effectiveness, TNT = 100: Fregmentation Tet/: Glazz Cones Steel Cones 90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc 1.33 Hole Volume 1.723 Hole Depth Charge Wt, Ib **Total No. of Fragments:** Color: 703 For TNT 519 For Subject HE 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 Fragmonts: . Method of Looding: Hand tamped 514 For TNT 428 For Subject HE Loading Density: gm/cc 1.35 Frequent Velocity: ft/sec At 9 ft At 251/2 ft Storages Density, gm/cc Method Dry Class 9 Blast (Relative to TNT): Hazard wines (Quantity-Distance) **Competibility Group** G: Oup I Airs Peak Pressure Exudation Impulse Energy Origin: Air, Confined: Impulse PIPE, a mechanical mixture of PETN and Gulf Crown E Oil, was developed in the United States during World War II. Under Water: Peak Pressure References: 61 Impulse (a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III-Miscellaneous Sensitivity Tests; Performance Tests, OSRD Re-port No. 5746, 27 December 1945. Energy Underground: Peak Pressure (b) S. Livingston, Properties of Explosives RIPE, PIPE and PEP-3, Picstinny Argenal Techni-cel Report 1517, 24 April 1945. Impulse Energy Preparation: PIPE is manufactured by simple mechanical mixing of FETN in oil.

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filsee footnote 1, page 10.

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AMCP 766-177

T. N

Plumbatol

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| Composition: | Molecular Weight: | 291 |
|---------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|--------------|
| % Lead Nitrate 70 INT 30 | Oxygen Belance: CO ₂ % CO % | -5.4 +9.3 |
| لى 11 | Density: gm/cc | |
| | Maiting Point: "C | |
| C/H Ratio | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Boiling Point: "C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 13 Sample Wt, mg 22 | Refrective Index, ng ng ng | |
| Friction Pundulum Test: | Vacuum Stability Test: | ····· |
| Steel Shoe | cc/40 Hrs, at 90°C | |
| Fiber Shoe | 94°C 163°C | |
| Rifis Sullet Import Test: Trials | 120°C | |
| % Explosions | 135°C | |
| Partials | 150°C | |
| Burned | 200 Gram Bamb Sand Test: | |
| Unoffected | Sond, gm | 32.4 |
| Explosion Temperature: *C Seconds, 0.1 (no cap used) | Sensitivity to Initiation: Minimum Detonsting Charge, gm | |
| 1 | Mercury Fulminate | |
| 5 Decomposes 230 10 | Lead Azide | 0.20 |
| 15 | Tetryi | 0.10 |
| 20 | Balliotic Morter, % TNT: | |
| | Trouzi Test, % TNT: | |
| 75°C International Host Test: % Loss in 48 Hrs | Plate Dont Test: Method | |
| 100°C Heet Test: | Condition | |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc | |
| Explosion in 100 Hrs | Brisonce, % TNT | |
| Fismmability Index: | Detensition Rate: (b) Confinement Condition | |
| Hygroscopicity: % | Charge Diameter, in. | |
| Volatility: | Density, gm/cc Rate, meters/second | 2.89 4850 |
| ويرجوه والمربوع والمربوع والمربوع فلنست والمربوع والمتعاد والمتحاد والمتحاد والمراجع المربع والمراجع والمراجع والمراجع والمراجع | | |

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Plumbatol

AMCP 706-177

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| Fregmentation Test: | Shaped Charge Effectiveness, TNT == 100: | | | | |
|--------------------------------------------------------------------------------------------|----------------------------------------------------------------|-----------------------------------------------|-------------|-------------|--|
| 90 mm HE, M71 Projectile, Lot WG-91: Density, gm/cc Charge Wt, lb | Gi Hole Volume Hole Depth | lass Cones 11 ¹ 4 103 | Steel Cones | (=) | |
| Total No. of Fragments: For TNT For Subject HE | Color: | · <u>·</u> ·································· | Light j | rellow | |
| 3 inch ME, M42A1 Projectile, Let KC-3: Density, gm/cc Charge Wt, Ib | Principal Uses: | | | | |
| Total No. of Fragments: For TNT | Mathed of Loading | ,:]: | | Cast | |
| For Subject HE Fregment Velecity: ft/sec | Looding Density: g | m/cc | | | |
| At 9 ft At 25½ ft | Sterage: | | <u> </u> | <u></u> | |
| Density, gm/cc | Mathod | | | Dry | |
| Blast (Reletive to TNT): | Hazard Class (Q | uantity-Dist | ance) | Class 9 | |
| Air: Peak Pressure Impulse Energy | Compatibility G | roup | | Group I | |
| Air, Confined: Impulse | Origin: An explosive and 30% TNT has usee of "Marcar: | been used | | | |
| Under Weter: Peak Pressure | References: 62 | | | | |
| Impulse Energy | (a) Eastern gation of Cavity Cavity Effect w | y Effect. | Sec III. Ve | ristion of | |
| Underground: Peak Pressure | Contract W-672-0 (b) Thorpet | ORD-5723. | | | |
| Impulse Energy | istry, Fourth Ed and Company, Lou p. 464. | dition, Vo | 1 IV, Long | mans, Green | |
| Preparation: | | | | | |
| Plumbetol is menufactured by simple mechanical mixing of lead nitrate in molten TNT. | | | | | |

62See footnote . page 10.

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PLX (Liquid)

| Composition: | | | Molecular Weight: | <u>100</u> 61 | <u>95/5</u> 61 |
|----------------------------------------------------------------|-------------|----------------------------------------|-----------------------------------------|------------------|----------------------------------------|
| % Nitromethane | 100 | * 95 | Oxygen Bulence: | ¥:• | ~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~ |
| Euhylenediamine | | 5 | CO, % | -39 | -48 |
| *The m xture 95/5 Nits | omethene/ | F | CO % | -13 | -21 |
| is designated PLX (fo sive). See note unde | or Picatini | y Liquid Explo- | Density: gm/cc | 1.14 | 1.12 |
| | <u></u> | | Melting Point: *C | -29 | |
| C/H Ratio | | | Freezing Point: "C | ······ | |
| Impact Sensitivity, 2 %: W Bureau of Mines Apr ara | | <u>100 95/5</u> 100+ 100+ | Boiling Point: "C | 101 | |
| Sample Wt 20 mg | | | Refractive Index, nm | | |
| Picatinny Arsenal A, par Sumple Wt, mg | atus, in. | 20 20 | ់ កង្ហ | | |
| admpne vi t, mg | | | nB | | |
| Friction Periculum Texts | | | | | |
| Steel Shoe | U | affected | Vecuum Stability Test: cc/40 Hrs, at | | |
| Fiber Shoe | Ui | mffected | 90°C | | |
| | | | 100°C | | |
| Cifie Bullet Impact Trat: 1 | 0 Trials | 5 Triels | 120°C | | |
| Exclosions | % 0 | Č | 135°C | | |
| Portials | o | 0 | 150°C | | |
| Sumed | Ö | 0 | 200 Grem Bemb Send Te | 100 | 95/5 |
| Unaffected | 100 | 100 | Sand, gm | 8.1 | 50.6 |
| Ezyletian Temperature: | •℃ | <u>ەن</u> | Seasitivity to Initiation: | | |
| Seconds, 0.1 | 100 | 22/5 | Minimum Detonating | Charge, gm | |
| 1 | | | Mercury Fulminote | | |
| 5 | 430 | 430 | Leod Azide | | |
| 10 | | | Tetry | | |
| 15 | | | B-11-11-14 | | |
| 20 | | | Jaliistic Morter, % THJ | · | |
| 73°C International Heat To | | | Trauxi Test, % 14 | 127 | |
| % Loss in 48 Hrs | | | Plote Dent Test: Method | | |
| 100°C Heet Test: | | | Condition | | |
| % Loss, 1st 48 Hrs | | | Confined | | |
| % Locs, 2nd 48 Hrs | | | Density, gm/ce | | |
| Explosion in 100 Hrs | | | Brisonce, % TNT | | |
| Flammability Inéos: | | | Detonution Rates | 1/32"* | 1/32"* |
| | | | Confinement | Glass | Glass |
| Hygrescopicity: % | | | Condition | Liquid | <u>Liquid</u> |
| | | | Charge Diameter, in. | | 0.94 |
| Vələtility: | | ······································ | Density, gm/cc | 1.14 | 1.12 |
| - | | | *Tube wall thickness | 0510 | 6165 |

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PLX (Liquid)

AMCP 706-177

| Booster Sensitivity Test: <u>N11</u> Condition Tetryl, gm Wax, in. for 50% Detonation Wax, gm | romethane. | Decemposition Equation: Oxygen, atoms/sec (Z/sec) Heat, kilocalorie/mole (ΔH, kcai/mol) Temperature Ronge, *C | (d) | Vitromethane 10 ^{14.0} 56.6 330-430 |
|-----------------------------------------------------------------------------------------------------------|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------|----------------|------------------------------------------------------------------|
| Density, gm/cc | | Phase | | Gaseous |
| Heat of: Combustion, cal/gm | (*) 2830 | Armer Plate Impact Test: | | |
| Explosia), cal/gm Gas Volume, cc/gm | | 60 mm Moster Projectile 50% Inert, Velocity, f | | |
| Formation, cal/gm Fusion, cal/gm | -348 | Aluminum Fineness | | |
| Vaporization, cal/gm | 149 | 500-lb General Purpese I | fondbe: | |
| Spelific Heet: cal/gm/°C (b) C = 0.4209 - 0.00076t + 0.00 p for 15°C to 70°C | 00061t ² | Plate Thickness, inche | 15 | |
| | | 1 | | |
| • | | 14 | | |
| | | 13 <u>4</u> 175 | | ÷ |
| Surning Rote: | | | | |
| cm/sec | | Sumb Drep Tutt: | | |
| Thermal Conductivity: | ······································ | | | |
| cal/sec/cm/°C | | T7, 2029-16 Semi-Armer | -Piercing Bami | ve Centrale: |
| Co.fficiant of Expension: | | Max Safe Drop, ft | | |
| Linear, %/°C | | 500-16 General Purpose | Bemb vs Cerc | rete: |
| Volume, %/*C | | Height, ft | | • |
| Hardness, Mak " Szale: | | Triais Unaffected | | |
| | | | | |
| Young's Modulus; | | High Order | | |
| E', dynes/cm² | | | | |
| E, Ib/inch ^a | | 1000-lb General Purpose | Bemb vs Conc | refe: |
| Density gm/cc | | Martaka An | | |
| Compressive Strongth: Ib/inch* | | Height, ft Trials | | |
| | | Uncflected | | |
| Vepar Pressure: | (c) | Low Order | | |
| *C mm Mescury | | high Order | | |
| 70 258 85 444 | | | | |
| | | | | |

PLX (Liquid)

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| 90 man HE, M71 Projectila, L.: WC-91: Density, gn/cc Glass Cones Steel Cones Density, gn/cc Hole Volume Hole Depth Tetel Ns. of Fregments: For T.NT Color: Light yellow 93 lack HE, M42A1 Projectile, Let KC-5: Density, gn/cc Principal Uses: MinefielA clearing 94 mainty, gn/cc Charge Wt, Ib Principal Uses: MinefielA clearing 95 mainty, gn/cc Charge Wt, Ib Principal Uses: MinefielA clearing 95 mainty, gn/cc Charge Wt, Ib Pumping Ecoding Density: gn/cc 1.00 25/5 7 breageneet Valeethy: ft/sec A: 9 th A: 1.12 1.12 1.12 7 breageneet Valeethy: ft/sec A: 9 th Storege: Nethod Components stored separately; mixed only when ready to use 9 biset (Reletive to TNT): Hostord Class (Quanility-Distonce) Compatibility Group Exudation Air, Coesinest: Impulse Minimum Propegating 100 95/5 Under Weter: Pack Pressure Yiscosity, centipoises: (e) 7 map, 10°C 0.748 | Frequentation Test: | Shaped Charge Effectiveness, TNT = 160: | | | | |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|
| For T NT Celer: Light yellow 3 inch ME, M42A1 Projectile, Let KC-3: Principal Uses: Minefiel4 clearing 3 inch ME, M42A1 Projectile, Let KC-3: Density, gm/cc Charge Wi, ib Tetsi Ne, of Fregments; Method of Leading: Pumping For TNT For Subject HE Leading Density; gm/cc 100 25/5 Pregmente Velecity: ft/sec At 25% it Storege: Method of Leading: Pumping Jack ME Leading Density: gm/cc 100 25/5 1.14 1.12 Pregmente Velecity: ft/sec At 25% it Storege: Method components stored separately; mixed only when ready to use Wathod Components stored separately: mixed only when ready to use Hazard Class (Quentity-Distore) Ab: Peak Pressure Exudation Exudation Under Water: Viscosity, centipoises: (*) Peak Pressure Yiscosity, centipoises: (*) Viscosity, centipoises: (*) Temp, 10°C 0.788 | Density, gm/cc | Hole Volume | | | | |
| 3 iack HE, M42A1 Projectile, Let KC-5: Principal Uses: Minefiel? clearing 3 iack HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib Method of Looding:: Tetul Ne. of Fregments: Method of Looding:: For TNT For Subject HE Leeding Density: gm/cc 1.00 At 25½ it Density, gm/cc Density, gm/cc Method Components stored separately; mixed only when ready to use Blact (Existive to TNT): Heard Class (Quontity-Distance) Abr Compositibility Group Peak Pressure Exudation Minimum Propagating 100 95/5 Minimum Propagating 0.05 0.063 Under Water: Pressure (e) Peak Pressure Thickness, ini 0.5 | For T NT | Color: Light yellow | | | | |
| For Subject HE Looding Density: gm/cc 100 95/5 Pregnant Velecity: ft/sec 1.14 1.12 At 9 fr At 25½ it Storage: Dansity, gm/cc Method Components stored separately; mixed only when ready to use Blact (Relative to TNT): Hazard Class (Quantity-Distance) Air: Peak Prossure Exudation Impulse Exudation 95/5 Under Water: Yiscosity, centipoises: (e) Under Water: Temp, 10°C 0.748 | 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, ib Tetal No. of Fregments: | | | | | |
| Pregment Velocity: fr/sec At 9 fr At 25½ ft Donsity, gm/cc Method Components stored separately; mixed only when ready to use Viscot (Reletive to TNT): Air: Peak Pressure Impulse Minimum Propagating 100 95/5 Thickness, in: 0.5 Viscosity, centipoises: (*) Viscosity, centipoises: (*) Temp, 10°C 0.748 | | | | | | |
| Blast (Roletive to TNT): Hazard Class (Quantity-Distance) Air: Compatibility Group Peak Pressure Exudation Impulse Exudation Air, Confined: Impulse Impulse 100 95/5 Under Water: Viscosity, centipoises: (*) Peak Pressure Temp, 10°C 0.748 | At 9 ft At 251/2 ft | Statege: Method Components stored separately; | | | | |
| Impulse 25°C 0.625 Evergy 40°C 0.533 Underground: Compatibility with Metals: Peak Pressure Stainless steel, mild steel and duriron not sffected; corrodes brass. Enorgy Enorgy | Ab: Peak Prossure impulse Zinergy Air, Canfined: Impulse Under Water: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse | Hazard Class (Quantity-Distance) Compatibility Group Exudation Minimum Propagating 100 95/5 Thickness, in: 0.5 0.063 Viscosity, centipoises: (*) Temp, 10°C 0.748 25°C 0.625 40°C 0.533 Compatibility with Metals: Stainless steel, mild steel and duriron | | | | |

FLX (Liquid)

AMCP 706-177

Origin:

Nitromethane has been known since 1872 (Kolbe, J prakt Chem (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 nitromethane produced as a by-product of the nitration of propane (U. S. Patent 1,967,667 (1934); British Patent 443,707 (1937); and Canadian Patent 371,007 (1938).

The development of nitromethane liquid explosives was based on information that nitromethane is sensitized to initiation and propagation of detonation by the addition of various amines. This study made at Ploatinny Arsenal in 1945 indicated that mixtures of nitromethane with 5% of ethylenediamine, n-butyl-amine, or morpholine showed considerable promise for application in mine-field clearance (L. H. Eriksen and J. W. Rowen, PATE No. 1565, 17 September 1945).

References:63

(a) D. E. Holcomb and C. F. Dorsey, "Thermodynamic Properties of Nitroparaffins," Ind Engr Chem <u>41</u>, 2788 (1949).

(b) J. W. Williams, "A Study of the Physical Properties of Nitromethane," J Am Chem Soc 47, 2644 (1925).

(c) L. Medard, "Explosive Properties of Mitromethane," Men poudr 33, 125 (1951).

(d) T. L. Cottrell, T. E. Graham and T. J. ∴vid, "The Thermal Decomposition of Nitromethanes," Transactions of the Farsiay Society <u>47</u>, 584 (1951).

(c) F. Bellinger, H. B. Friedman, W. H. Bauer, J. W. Eastes and W. C. Bull, "Chemical Propellants: Stability of Monomitromethane," Ind Engr Chem <u>h0</u>, 1320 (1948).

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

| <u>o</u> | 1 | 3 | ٤ | <u>6</u> | I | 8 | 2 |
|----------|--------------|------|--------|----------|------|------|------|
| 1660 | 1681 1831 | 2113 | 1565 - | 2016 | 1747 | 1708 | 1619 |

63See footnote 1, page 10.

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AMCP 706-177

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Potassium Dinitrobénzfuroxan (KDNEF)

| Composition: | Meleculer Weight: (KC6H4N406) | 225 |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------|
| % C 27.3 H 0.4 N 21.2 | Oxygon Balence: CO2 % CO % | -60 -18 |
| $\begin{array}{c c} n & 21.2 \\ 0 & 36.3 \\ 0_{2}N \\ \end{array}$ | Density: gm/cc | 2.21 |
| к 14.8 | Melting Point: "C Explodes | 210 |
| C/H Ratio 0.416 | Freezing Point: *C | |
| Import Sanshivity, 2 Kg We: | Bailing Paint: *C | |
| Bureau of Mines Apparatus, cm | Refrective Index, ng ng ng | |
| Friction Pendulum Test: Steri Shoe Skiplodes Fiber Shoe Explodes | Vacuum Stability Test: cc/40 Hrs, at 90°C | <u></u> |
| Rifle Bullet Impoct Test: Trials % Explosions Partials | 100°C 120°C 135°C 150°C | |
| Burned Unaffected | 200 Grem Bomb Soud Tasts Sand, gri Black powley Suge 9.5 | 43.6 |
| Explacion Temperature: *C Seconds, 0.1 (no cop used) 1 5 250 10 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate 0, 30 Load Azide Tetry! | 0.20 0.10 |
| 15 20 | Sallistic Marter, % TNT: | |
| 75°C International Heat Test: | Trausi Test, % TNT: | <u> </u> |
| % Loss in 48 Hrs | Plote Deat Test: Method | |
| 100°C Heet Test: 0.03 % Loss, 1st 48 Hrs 0.03 % Loss, 2nd 48 Hrs 0.05 Explosion in 100 Hrs None | Condition Confined Density, gm/cc Brisonce, % TNT | |
| Flammability Index: | Detenation Ratès Confinement | <u></u> |
| Hygroscopicity: % 30°C, 75% RH 0.11 30°C, 90% PH 0.27 | Condition Charge Diameter, in. | |
| Veletility: | Density, gm/cc Rate, meters/second | |

Potassium Dinitrobenzfuroxan (KDNBF)

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AMCP 706-177

| Besster Seasitivity Test. Condition | | Decompositiva Equation: |
|----------------------------------------|---------------------------------|---------------------------------------------------|
| | | Oxygen, atoms/sec (Z/sec) |
| Tetryl, gm | | Heat, kilocolorie/mole |
| Wax, in. for 50% Detanation | | (AH, kcal/mol) |
| Wax, gm | | Temperature Range, *C |
| Density, gm/cc | | Phase |
| Heat of: | 2209 | Armor Pioto Imaget Test; |
| Combustion, cal/gm | 725 | |
| Explosion, cal/gm | (<i>2</i>) 604 | 60 mm Martar Projectile: |
| Gas Volume, cc/gm | 604 | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | | Aluminum Fineness |
| Fusion, col/gm | | |
| | | 500-16 General Purpose Bombs; |
| Specific Heet: cal/gm/*C (♭) | | Plate Thickness, inches |
| ~50 | 0.217 | |
| 0 | 0.217 | |
| 25 | 0.217 | 11/4 |
| 50 | 0.217 | 11/2 |
| Burning Rote: | | |
| cm/sec | | |
| | | Bomb Drop Test: |
| Thermal Conductivity: | | |
| col/sec/cm/*C | | 17, 2000-15 Semi-Armor-Ploreing Bomb vs Concrete: |
| Coefficient of Expension: | | Max Safe Drap, ft |
| Linear, %/*C | | 500-16 General Purpose Samb ve Concrete: |
| | | |
| Volume, %/*C | | Height, ft |
| | | Triais |
| Hardness, Make' Seale: | | Unaffected |
| Young's Modulus: | يعينينانيه ومنصحيين منطبق ويكوج | Low Order |
| - | | High Order |
| E', dynes/cm² | | |
| E, Ib/Inch* | | 1000-lb General Purpase Samb vs Concrete: |
| Density, gm/cc | | |
| Compressive Strength: Ib/Inch" | | |
| Compreserve prrongrat 107 mcr- | | Triots |
| | | Unaffected |
| Vapar Pressure: | | Low Order |
| *C mm Mercury - | | High Order |
| | | |
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AMCP 706-177

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Potassium Minitrobenzfuroxan (KDNBF)

| Fregmentation Test: | Shaped Charge Effective.com, TNT = 100: | | | | |
|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|
| 90 mm HE, Ju71 Pmj2×3le, Lot WC-91: Density, gm/cc Charge Wt, lb | Glass Cones Steel Cones Hole Volume Hale Depth | | | | |
| Total No. of Fragments: For TNT | Celer: Orange to brown | | | | |
| For Subject HE 3 inch HE, M42A1 Projectile, Lot KC-3: Density, gm/cc Charge Wt, Ib | Primary explosive | | | | |
| Total Ne. of Fragments: For TNT | Mothed of Looding: Pressed | | | | |
| For Subject HE Fregment Velscity: ft/sec At 9 fc At 25½ ft Density, gm/cc | Loading Density: gm/cc psi x 10 ³ 10 20 30 40 80 1.63 1.77 1.81 1.86 1.98 Storage: Method Uut | | | | |
| Blast (Reletive to TNT): | Hazard Class (Quantity-Distance) Class 9 | | | | |
| Air: Peak Pressure Impulse Energy | Compatibility Group Group M (wet) Exudation | | | | |
| Air, Conflaod: Impulse | Solubility in Water, gm/100 gm solvent, at: 30°C 0.245 | | | | |
| Under Weter: Pook Pressure Impulse Energy | Stab Sensitivity: Density Firing Point (inch-ounces) gm/cc 0% 50% 100% 1.63 73 79 1.77 66 75 83 | | | | |
| Underground: Peak Pressure Impulse Energy | $ \begin{array}{cccccccccccccccccccccccccccccccccccc$ | | | | |
| | Activation Energy: kcal/mol 82.6 Induction Period, sec 0.5-10 | | | | |
| | | | | | |

Potassium Dinitrobenzfuroxan (KDNBF)

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AMCP 706-177

Preparation of Potassium Salt of 4,6-dinitrobenzfuroxan: (a)

Benzfurowan, made by the reaction of ortho-nitroaniline and alkaline sodium hypochlorite, was dissolved in 6 parts of 96% sulfuric acid and nitrated at $5^{\circ}-20^{\circ}$ C with s 4 to 1 sulfuricnitric acid mixture. The salt was prepared by neutralization of the 4,6-dinitrobenzfurowan with potassium bicsrbonate 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-dinitrobenzfuroxan was first prepared in 1899 by von P. Drost (Ann 307, 56 (1899)).

References: 64

(a) R. J. Gaughran, J. P. Picard and J. V. R. Kaufman, "Contribution to the Chemistry of Benzfurowan Derlvatives," J Am Chem Soc <u>76</u>, 2233 (1954).

(b) C. Lenchitz, Ice Calorimeter Determination of Enthalpy and Specific Heat of Eleven Orgunometallic Compounds, PATR No. 2224, November 1955.

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

| 2 | <u>, 3</u> | <u>6</u> | | 2 |
|------|------------|----------|---|------|
| 2122 | 2093 | 2146 | • | 2179 |

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PTX-1

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| Composition: % | | 24olecular Weight: | 252 |
|---------------------------------------------------|-------------|----------------------------------|----------------|
| RDX | 30 | Oxygen Balance: | her |
| Tetryl | 50 | CO % | -45 - 9 |
| TNT | 20 | Density: gm/cc | 1.68 |
| INI | ζŲ | Melting Point: *C Eutectic | 67 |
| C/H Ratic | | Freezing Point: *C | |
| Impact Sansitivity, 2 Kg Wt: | | Boiling Point: *C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | 44 | Refractive Index, nº | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | | ពដ្ឋ | |
| | | n 🔓 | |
| Friction Pendulum Test: | | Vacuum Stability Test: | |
| Steel Shoe | | cc/40 Hrs, at 90°C | |
| Fiber Shoe | | - 100°C | 3.0 |
| Rifiz Bullet Impact Test: Trials | | 120°C | J. C |
| % Explosions 20 | | 135°C | |
| Partials 20 | | 150°C | |
| Burned 0 | | 200 Gram Bamb Sand Yest: | |
| Unaffected 60 | _ | Sand, gm | 54.8 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | | Mercury Fulminate | 0.23* 0.22* |
| 10 | | | 0.22* |
| 15 | | *Alternative initiating charges. | |
| 20 | | Ballistic Morter, % TNT: (a) | 132 |
| 75°C International Heat Test: | | Trauzi Test, % TNT: | |
| % Loss in 48 Hrs | | Plere Dent Test: (b) Method | _ |
| | | Condition | B Cast |
| 100°C Heet Test: | | Contined | No |
| % Loss, 1st 48 Hrs % Loss, 2nd 48 Hrs | | Dansity, gm/cc | 1.68 |
| Explasion in 100 Hrs | | Brisance, % TNT | 127 |
| | | Detenation Ratu: | |
| Flammability Index: | | Confinement | None |
| Hygroscopicity: % | | - Condition | Cust · |
| 30°C, 90% RH, 15 days | 0.00 | Charge Diameter, in. | 1.0 |
| Veletility: | | Density, gm/cc | 1.64 7655 |
| | | Rote, meters/second | (ככס |

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<u>PTX-1</u>

| Fragmentation Test: | | Shaped Charge Effectiveness, TNT | =: 100: |
|---------------------------------------------------|--------------|--------------------------------------------------------------------------------------------------|--------------------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: | | Glass Cones Sto | eel Cones |
| Density, gm/cc | 1.64 | Hole Volume | |
| Charge Wt, Ib | 2.180 | Hole Depth | |
| Total No. of Fragments: | | Celer: | |
| For TNT | 703 | | |
| For Subject HE | 999 | Principal Uses: Land mines and | demolition |
| 3 inch HE, M42A1 Projectile, Lot KC-5: | | charges | |
| Density, gm/cc | 1.63 | | |
| Charge Wt, ib | 0.864 | | |
| Total No. of Fragments: | | Method of Looding: | Cast |
| For TNT | 514 | | |
| For Subject HE | 685 | Looding Density: gm/cc | 1.68 |
| Fragment Velocity: ft/sec | | | 1.00 |
| At 9 ft | 2690 | | |
| At 251/2 ft | 2460 1.64 | Storage: | |
| Density, gm/cc | 1.04 | Method | Dry |
| Slast (Relative to TNT): | | Hazard Class (Quantity-Distance |) Class 9 |
| Air: | (d) | Compatibility Croup | Group I |
| Peak Pressure | <u>111</u> | | |
| Impulse | 109 | Exudation | Exudes at 65°C |
| Energy | •• | | |
| Air, Confined: | | Preparation: | |
| Impulse | | The ternary explosive sys | |
| Under Water: Peak Pressure | ·• | RDX, tetry 1 and TNT is prepar appropriate weight of we'cer- tol (40/60) previously melter | wet RDX to a tetry- d in a steam- |
| Impulse | | jacketed melt kettle. Heating are continued until all the | |
| Energy | | and the mixture is uniform in PTX-1 is also prepared by add | n composition. |
| Underground: Peak Pressure | | Composition B. | |
| Impulse | | | |
| Energy | | Dry: Aluminum, mild stee | L not BIIected. |
| Booster Sensitivity Test: (c) | | Wet: Aluminum, mild steel | l not affected. |
| Condition Press | | | |
| Tetryl, gm 100 Wax, in. for 50% Detonation 1.4 | | | |
| | 61 1.62 | 1 | |

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TAS A DECIMANT

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PTX-1

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Origin:

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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. 1.11, 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</u> ternary explosive mixtures suggested by the Russian fillers, a mixture consisting of <u>RDK/tetryl/TNT</u>, designated PTX-1 was developed which had explosive and physical properties offering considerable advantage for military applications (PATR No. 1360, 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°C without exudation.

References: 65

(a) L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, Part <u>III</u> - <u>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) 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.

(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 | 6 | ĩ | 2 |
|----------|------|------|--------------|------|----------------------|
| 1530 | 1402 | 1623 | 1466 1506 | 1437 | 1379 1429 1469 |

⁶⁵See footnote 1, page 10.

PTX-2

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| | Malacular Weisht: 244 | 243 |
|----------------------------------------------------------------------|------------------------------------------|--------------|
| Composition: % | Molecular Weight: 244 | 243 |
| RDY 44 - 41 | Oxygen Baleace: CO ₂ % -33 | - 36 |
| PETN 28 - 26 | CO % ⁵ - 3 | - 4 |
| INT 28 - 33 | Density: gm/cc | 1.70 |
| | Molting Points *C Eutecti | c 75 |
| C/H Ratio | Freezing Point: *C | |
| Impact Sumilifyit /, 2 Kg Wt: Bureau of Minus Apparatus, cm 35 | Boiling Paint: "C | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg | Refrective Index, ng ng ng | |
| Friction Pondulum Test: | Vocuum Stability Test: | |
| Steel Shoe CruckLes Fibur Shoe | cc/40 Hrs, at 90°C | |
| Alda Ballat farmer at Walter | | 2.6 |
| Rifla Bullet Import Teet: Trials | 120°C | 11+ |
| Explosions 60 | 135°C | |
| Partials 0 | 150°C | |
| Burned 0 | 200 Gress Bomb Sund Test: | |
| Unoffected 40 | Sand, gm | \$6.9 |
| Explosion Temperature: *(, | Sanaitivity to Initiations | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | |
| 1 5 | Mercury Fulminate Load Axide | 0.21 |
| 10 | Leco Azide Tetryi | 0.00 |
| 15 | i urry? | 0.00 |
| 20 | Ballistic Martar, % TNT: (a) | 138 |
| 75°C Internetional Haat Test: | Treasel Test, % TNT: | |
| % Loss in 48 Hrs | Plate Dant Test: (b) Method | в |
| 100°C Heat Test: | Condition | Cast |
| % Loss, 1st 48 Hrs | Confined | No |
| % Loss, 2nd 48 Hrs | Density, gm/cc | 1.71 |
| Explosion in 100 Hrs | Brisonce, % TNT | 141 |
| Fiemmebility Index: | Detenation Rate: Continement | Vana |
| | | None Cast |
| | | 1.0 |
| Hygroscopicity: % | | |
| Hygrescepicity: % 30°C, 90% RH, 15 days 0.00 | Charge Diameter, in. — Density, gm/cc | 1.70 |

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PTX-2

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ASCP 706-177

Shaped Charge Effectiveness, TNT == 160: Fregmentation Text: 90 mm HE, M91 Projectilo, Let WC-91: Glass Cones Steel Cones Density, gm/cc 1.68 ~130 Hole Volume 2.226 **Hole Depth** Charge Wt, Ib Total No. of Fragmonts: Color: For TNT 703 For Subject HE 1128 Shaped charges Principal Uses: Fragmentation charges 3 inch HE, M42A1 Projectile, Let KC-5: Density, gan/cc 1.70 0.897 Charge Wi, ib **Total Has of Proymonts:** Method of Louding: Cast 514 For TNT For Subject HE 750 1.70 Londing Density: gm/cc Frequent Valechys ft/soc At 9 ft At 25½ ft 3020 2850 Storege: Density, gm/cc 1.70 Method Dry Hazard Class (Quantity-Distance) Start (Relative to TNT): Class 9 **Compatibility Group** Group I (d) 113 Aler Peak Pressure None at 65°C 113 Exudation Impulse Energy ---Preparation: Air, Confined: Impulse The termary explosive system consisting of RDX, PETN and TNT is prepared by adding the appropriate weight of water-wet RDX to a pen-Under Water: tolite (30/70) previously melted in a steam-Puck Pressure jacketed melt kettle. Heating and stirring Impulse are continued until all the water is evaporated Energy and the mixture is uniform in composition. PTX-2 is also prepared by adding water-wet PETM to RDX Composition B. Underground: Peak, www. Compatibility with Metals: Impulse Dry: Aluminum, mild sidel not affected. Energy Wet: Aluminum not effected. Booster Sensitivity Test: (c) Condition Pressed Cast Tetryl, gm 100 100 Max, in. for 50% Deconation 1.87 2.32 Density, ga/cc 1.61 1.70

AMCP 706-177

Origin:

The possibility of employing ternary mixtures to obtain explosives having greater power and higher brisance than binar, mixtures was suggested by the analysis of Russian 76 mm, ermorpiercing high explosive rounds (PATR No. 1311, 17 July 1943). The Russian type Gernary 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 RDX/PETN/TNT, designated PTX-2 was developed which had explosive and physical properties offering considerable advantage for military applications (PATR No. 1360, 27 October 1943; and 1379, 11 January 1944).

PTX-2

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, PTX-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. Eyster, <u>Physical Testing of Explosives</u>, Part III - <u>Miscellaneous</u> Sensitivity Tests; <u>Performance Tests</u>, OSRD Report No. 5745, 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, <u>A Consideration of RDX/Wax Mixtures as a Substitute for</u> Tetryl in Boosters, NOL Memo 10,303, 15 June 1949.

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

(c) Also see the following Picatinny Arsenal Technical Reports on PTX-2:

| 2 | <u>2</u> | <u>3</u> | 4 | 2 | <u>6</u> | <u>8</u> | 2 |
|------|----------|--------------|------|------|----------|----------|----------------------|
| 1530 | 1482 | 1483 1623 | 1414 | 1445 | 1466 | 1838 | 1379 1429 1469 |

66See footnote 1, page 10.

-22

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| Composition: | | Melecular Weight: | 217 |
|--------------------------------------------------------------|------------|---------------------------------|------------|
| % SDX | 90 | Oxygen Belence: | |
| | - | CO: % CO % | -37 -10 |
| Polyvinyl Acetate | 8 | | 1.60 |
| Dibutylphthalate | 5 | | 1.00 |
| # 151 D-41- | | Softening Point: °C | - 92 |
| C/H Rotio | · · · | Freezing Point: *C | |
| mpect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 39 | Boiling Point: *C | |
| Sample Wt 20 ing | | Refrective Index, no | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 9 13 | n <u>B</u> | |
| | | ng | |
| friction Pondulum Test: | | Vecuum Stebility Test: | |
| Steel Shoe | Crackles | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifle Bullet Impact Test: 5Trials * | • | | 0.45 |
| | | 120°C | 0.88 |
| Supiosions 20 | | 135°C | |
| Partials 0 | | 150°C | 11+ |
| Burned 60 | | 200 Gram Bamb Sand Test: | |
| | | Sand, gm | · 58.5 |
| *100 trials at -46°C - Unaffe | ected | | |
| Explasion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cop used) | | Minimum Detonating Charge, gm | |
| 1 330 5 Decomposes 375 | | Mercury Fulminote | |
| | | Leod Azide | 0.22 |
| | | Tetryi | |
| 15 20 | | Ballistic Martur, % TNT: | |
| | | Trauzi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | | Plate Dent Test: | |
| | | Method | |
| IOO"C Heet Test: | | Condition | |
| % Loss, 1st 48 Hrs | 0.10 | Confined | |
| % Loss, 2nd 48 Hrs | 0.06 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisance, % TNT | |
| Fismmability Index: | | Detenstion Rate: Confinement | Vene |
| | | | None |
| Hygrescepicity: % 30°C, 90% RH | 1 0.20 | Condition | Cast |
| | | Charge Diameter, in. | 1.0 |
| | | - Density, gm/cc | 1.60 |

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| ragmentation Test: | Shaped Charge Effectiveness, | înt = 100: |
|-----------------------------------------|----------------------------------------|-----------------------------------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: | Glass Cones | Steel Cones |
| Density, gm/cc | Nole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total He. of Fregments: | Celera | White |
| For TNT | | *41 V |
| For Subject HE | Principal Uses: | Demolition charges |
| 3 inch HE, MAZA'I Projectile, Let KC-3: | | |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fragments: | Method of Londing: Pro | esed or extraded |
| For TNT | | teed of exchanged |
| For Subject HE | Looding Density: gun/cc | 1.60 |
| rugment Velocity: ft/sec | | |
| At 9 ft At 25½ ft | Storege: | ىي (14 شە111 بورىنىيە قەتلەت بىلىپىنىيەن ئىدىنەت ئىرى بەت |
| Density, gm/cc | | |
| | Method | Iny |
| liest (Relative to TNT): | Hazard Class (Quantity-Dis | tonco) Class 9 |
| Alm | Compatibility Group | Group I |
| Peak Pressure | Exudation | None at 71°C |
| Impulse Energy | EAGODINH | NORE ST II C |
| chergy | ······································ | والمؤواة الجريري المتخاصة ومعتمدة فأبا التؤسيلية |
| Air, Confined: | Plasticity: | |
| Impulse | -40°C | Cracked |
| Under Weter: | 25 ⁰ C | |
| Peak Pressure | 2 7 0 | 0.3, |
| impulse Energy | | |
| Chargy | | |
| Underground: Peak Pressure | | |
| Impulse | | |
| Energy | | · |
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PVA-4

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Preparation:

Explosive PVA-4, a semi-plastic composition of Canadian origin, consists of 90% RDX, 8% polyvinyl acetate and 2% dibutylphthalate (DBP). This formulation was developed by Dr. Sutherland of Shawinigan 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 mamed or designation "AYAT" was the most promising costing for RDX in the proportions RDX/PVA(AYAT)/DBP 92/6/2.

A practical method of preparing this composition was by the addition of a solution of the coating agent to an aqueous RDX slurry. Based on the quality of the product and the pellet densities obtained, a procedure of adding an acetone solution of PVA + DEP to a hot water slurry of RDX, under agitation, was adopted as standard.

References: 67

(a) See the following Picatinny Arsenal Technical Reports on PVA-4: 1532 and 1634.

67See footnote 1, page 10.

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PVN (Polyviny) Nitrate)

AMCP 706-177

-3

| Composition: | | Melecular Weight: (C2H3NO3 |) _n (89) _n |
|---------------------------------------------------------------|----------------------------------------|-------------------------------------------|----------------------------------|
| % C 21 | | Oxygen Balance: CO2 % | -45 |
| Н 3.4 /н с-си-оно | | % OD | - 9 |
| (H ₂ C-CH-ONO N 15.6 | 2/n | Density: gm/cc | |
| o 54 | | Melting Point: "C (Soft P | b) 50 |
| C/H Ratio 0.203 | | Freezing Point: *C | |
| Impoct Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 14,864N | Boiling Point: "C Refrective Index, ng | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. | 4 | | |
| Sample W?, mg | | n | |
| | | n <mark>e</mark> | |
| Friction Pendulum Test: | | Vocuum Stability Test: | |
| Steel Shoe | Crackles | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | 6 hours 11+ |
| Rifie Bullet import Yest: Trials | | | 6 hours 11+ |
| 96 | | 135°C | |
| Explosions | | 150°C | |
| Partials | | | |
| Burned | | 209 Gram Bomb Sond Test: |) – – |
| Unoffected | | Sand, gm | 49.9 |
| Explation Temperature: * *C | | Semitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, | gm |
| 5 265 | | Mercury Fulminate | |
| 10 | | Leod Azide | |
| 15 | | Tetryl | |
| 20 | | Beilistic Mortor, % THT: | |
| | | Treusi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | | Plate Dent Test: | |
| | | Method | |
| 100 °C. Heat Test: | | Condition | |
| % Lous, 1st 48 Hrs | 1.9 | Confined | |
| % Loss, 2nd 48 Hrs | 2.1 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisonce, % TNT | |
| Fiemmability Index: | | Detenation Rate: Confinement | |
| Hygrescepicity: % 30°C, 90% RH | 0.62 | Condition Charge Diameter, In. | |
| Volotility: | ······································ | Density, gm/cc | |
| | | Rote, meters/second | , |

AMCP 706-177

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PVN (Polyvinyl Nitrate)

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| Fregmentation Test: | Shaped Charge Effectivaness, 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: | Celer |
| For TNT | |
| For Subject HE | Principal Uses: |
| 3 Inch HE, M42A1 Projectile, Let XC-5: | |
| Density, gm/cc | |
| Charge Wt, Ib | |
| Total No. of Fregments: | Method of Loading: |
| For TNT | • |
| For Subject HE | Landing Density: gm/cc |
| Revenue and Male they to the | |
| Fregment Velecity: ft/sec At 9 ft | |
| At 251/2 ft | Storagez |
| Density, gm/cc | Method |
| Bleet (Relative to TNT): | Hazard Class (Quantily-Distance) |
| Ain | Compatibility Group |
| Peak Pressure | Exudation |
| Impulse | EXUDERION |
| Energy | |
| Air, Contined: | 65.5°C KI Test: |
| Impulse | Minutes 60+ |
| Under Water: | 134.5°C Heat Test: Minutes |
| Peak Pressure | Selmon Pink 20 |
| Impulse | Red Fumes 25 |
| Energy | Explodes 300+ |
| Underground: | 240-Hour Hydrolysis Test: |
| Peak Pressure | \$ HNO3 5.07 |
| Impulse | 5 |
| Energy | Heat of: |
| | Combustion, cml/gm 2960 |
| | Explosion, csl/gm 900 Cas Volume, cc/gm 838 |
| | |
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PVN (Polyvinyl Nitrate)

AMCP 706-177

Preparation:

Polyvinyl sloobol 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 stirred. The temperature is controlled by the rate of acid addition so that when all the acid has been added the temperature does not rise above $20^{\circ}C$.

When the nitration is complete, the mixture is drowned by allowing a fine stream of 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 proparation of polyvinyl nitrate was reported in 1929 by solution of polyvinyl al.cohol in concentrated sulfuric acid and treatment with nitrating acid at a temperature not over 50°C. (German Patent 537,303). Later patents issued relative to polyvinyl nitrate included U. S. Patent 2,118,487 (193²) and German Patent 737,199 (1943).

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| AMCP | 706- | 17 | 2 |
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RIPE

| Composition: % | | Melecular Weight: | 230 |
|----------------------------------------------------|-------------|-------------------------------|------------|
| RDX | 85 | Oxygen Belance: | |
| | - | CO: % | -70 -35 |
| Gulf Crown E Oil | 15 | Density: gm/cc Hand tamped | 1.37 |
| | | Melting Point: *C | |
| C/H Ratio | | Freezing Paint: "C | |
| Impact Sensitivity, 2 Kg Wt: | 53 | Boiling Point: *C | |
| Bureau of Mines Apparatus, cm Somple: Wt: 20 mg | | Refrective Index, nº | |
| Picatinny Arsenal Apparatus, in. | 13 25 | ns | |
| Sample Wt, mg | 25 | n2 | |
| Friction Pondulum Test: | | Vocuum Stability Test: | . <u></u> |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifle Bullet Impact Test: Trials | | | 0.34 |
| • • • • • • • • • • • • • • • • • • • • | | 120°C | 0.56 |
| % Explosions O | | 135°C | |
| Partials Q | | 150°C | |
| Burned O | | 200 Gram Bomb Sand Test: | |
| Unoffected 100 | | Sand, gm | 40.1 |
| Explosion Temparature: *C | | Susitivity to Iniciation: | |
| Seconds, 0.1 (no cop used) | | Minimum Detonating Charge, gm | |
| | | Mercury Fulminate | |
| 5 Decomposes; no valu | e ootained | Leod Azide | 0.20 |
| 10 | | Tetryi | |
| 15 20 | | Ballistic Morter, % TNT: (a) | 118 |
| ۲۷ | | Trousi Toot, % TNT: | |
| 75°C International Heat Test: | | Plate Dent Test: (b) | <u> </u> |
| % Loss in 48 Hrs | | Method | в |
| 100°C Heat Test: | · · · · | Condition Ha | nd tamped |
| % Loss, 1st 48 Hrs | 0.03 | Confined | No |
| % Loss, 2nd 48 Hrs | 0.04 | Density, gm/cc | 37 ، ۲ |
| Explosion in 100 Hrs | None | Brisonce, % TNT | 85 |
| | | Detenation Rate: | |
| Flammability Index: | | Confinament | None |
| | A (1 | Condition Ha | nd tamped |
| Hygroscopicky: % 30°C, 90% RH | 0.04 | Charge Diametzr, in. | 1.0 |
| Veletility: | ···· | Density, gm/cc | 1.37 |
| A PRESIMENT. | * GARTINEY! | | 7390 |

RIPE

AMCP 706-177

| Fragmentation Test: | | Shepid Charge Effectiveness, TNT = 100: | | | |
|---------------------------------------------------------|------------|-----------------------------------------|-----------------------------------------|------------------------------------------|--------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: | | | Gluis Cones | Steel Cones | |
| Density, gm/cc | 1.36 | Hole Volume | | | |
| Charge Wt, Ib | 1.766 | Hole Depth | | | |
| Total Na. of Fragmants: | | Colori | | | White |
| For TNT | 703 | | | | rill ge |
| For Subject HE | 592 | Principal Uses: | Plastic dem | olition ex | losive |
| 3 inch HE, MIZA1 Projectile, Let KC-5: | | | • • | | |
| Density, gm/cc | 1.42 | | | | |
| Charge Wt, Ib | 0.756 | | | | |
| Total No. of Fragments: | | Method of Load | | 17n m.d. An. | - <u></u> |
| For TNT | 514 | MEMON OF LODE | 18g: | Kand tamp | ea |
| For Subject HE | 501 | | · | | · |
| | | Louding Density: | i gm/cc | | 1.37 |
| Fregment Velocity; ft/sec At 9 ft | 2650 | | | | |
| At 251/2 tt | 2370 | Storage: | | | |
| Density, gm/c¢ | 1,395 | Method | | ; | Dry |
| Blast (Rolative to TNT): | | Hazard Class | (Quantity-Distor | ica) | Class 9 |
| Air: | | Compatibility | Group | (| Group I |
| Peak Pressure | | | None at 85° | C in 30 hr | 8 |
| Impulse | | Exudation | None at 95 ⁰ Exudes at 10 | C in 48 hr: 05 ⁰ (: in 118 | . |
| Energy | | <u> </u> | | | |
| Ale, Confined: | | Origin: | م ^{ر مر} مه تر | | |
| Impulse | | RIPE, a mech | anical mixtu | re of REX (| and Gulf |
| Under Weter: | | Crown E 011, 1 during World N | ma developed | | |
| Peak Pressure | | | 1964° 11 | | |
| Impulse | | References:68 | | | |
| Energy | | | Smith and E. | | |
| | | Testing of Eng Sensitivity Te | sts: Perform | t III - Min ance Tests | OSRD Re- |
| Underground: Peak Pressure | | port No. 5746, | | | |
| Impulse | | (b) D. P. M Testing, OSRD | AcDougall, M | ethods of 1 | Physical |
| Energy | | Les criss, contr | vabor.c No. O | JJ II MUS | 180 17461 |
| Preparation: | | (c) Also se Technical Repo | the follow | ing Picatin 1713. 160 | nny Arsena 5 and 1517 |
| RIPE is manufactured by simple mixing of RDX in oil. | mechanical | | | | / 1/1 |
| | | | | | |

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6HSee footnote 1, page 10.

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Silver Azide

| Cempseition: | Molecular Weight: (AgN ₂) 150 |
|-----------------------------------------------------------------|------------------------------------------------------------------------|
| % * | Oxygen Balance: |
| N 28.0 | CO ₂ % -5 |
| Ag 72.0 | CO % -5 |
| $A_{\mathcal{E}} - N = N = N$ | Density: gm/cc Crystal 5.1 |
| | Melting Point: "C (a) 251 Decomposes repidly above melting point to |
| C/H Ratio | Freezing Point: "C Silver and nitrogen. |
| Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 6 | Boiling Point: *C |
| Bureau of Mines Apparatus, cm 6 Sample Wt 20 mg | Refractive Index, ng |
| Picatinny Arsenal Apparatus, in. 3 Samole Wt. ma 18 | na |
| Sample Wt, mg 18 | n2 |
| Friction Pendulum Test: PA Small Apparatus | Vecuum Stebility Test: |
| Steel Shoe Detonates | cc/40 Hrs, at |
| Fiber Shoe Detonates | 90°C |
| Rifle Builet impact Test: Trials | 100°C |
| | 120°C |
| 50 Explosions | 135*C |
| Partials | 150°C |
| Burned | 200 Grem Bomb Sand Test: |
| Unaffected | Sand am (b) Black powder flige 18.9 |
| Explosion Tempsreture: *C | Sensitivity to Initiation: |
| Seconds, 0.1 (no cup used) 310 | Minimum Detonating Charge, gm |
| 1 | Mercury Fulminate |
| 10 | Lead Azide |
| 15 | Tetryl |
| 20 | Sellistic Morter, % TNT: |
| 75°C International Haat Test: | Treuxi Test, % $HE'ONC)_2$ (c) 85 |
| % Loss in 48 Hrs | Plate Dant Test: Method |
| 100°C Heet Test: | Condition |
| % Loss, 1st 48 Hrs | Confined |
| % Loss, 2nd 48 Hrs | Density, gm/cc |
| Explosion in 100 Hrs | Brisance, % TNT |
| Flommability Index: | |
| | Condition |
| Hygroscopicity: % (b) 25°C, 100% RH 0.04 | Charge Diameter, in. |
| | Density, gm/cc |
| Veletility: (,5°C, 24 hrs 0.00 | Rate, meters/second |

Silver Azide

AMCP 706-177

| Frequentation Test: | Sheped Charge Effectiveness, TNT \Rightarrow 10 | D: |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------------|---------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib | Giass Cones Steel Ca Hale Volume Hale Depth | nes |
| Total No. of Fregmants: For TNT 🔅 | Celer: White | to gray |
| For Subject HE 7 3 inch HE, M42A1 Projuctile, Let KC-5: Density, gm/cc | Principal Uses: Init | 'isters |
| Charge Wt, Ib Tetel No. of Fregments: For TNT For Subject HE | Mathed of Loading: Press | sea |
| · | Loading Density: gm/cc Varia | ible |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft | Storaga: | |
| Density, gm/cc | Method | Wet |
| Biast (Relative to TNT): | Hazurd Class (Quantity-Distance) | Class 9 |
| Airs Peak Pressure Impulse Energy | Compatibility Group Exudation | Group M None |
| Air, Confined: Impulse | Initiating Efficiency: Gramm 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 Weter (b) Aumonium hydroxide | Grams 0.006 Soluble |
| Underground: Peak Pressure Impulse | Nitric acid Ether (b) | Decomposes 0.017 |
| Every | Ethyl alcohol, 95# Acetone | 0.006 0.015 |
| Explosive Power: (1) | Unaffected by water and CO2. | (d) |
| Kilogram metera 192,000 % Mercury Fulminate 1.037 | Heat of: Explosion, cal/gm (c, d) Formation, cal/gm (e) | 452 67.8 |

AMCP 706-177

Silver Azide

Preparation:

 $NaN_3 + AgNO_3 \rightarrow AgN_3 + + NaNO_3$

Prepare the following aqueous solutions:

- a. 5% NaNa, sodium szide, 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 fastened to the stopcock of the separatory funnel so that the funnel can be emptied by remote control. The silver nitrate solution is now stirred very rapidly and the sodium azide 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 washed free of sodium azide and silver nitrate with distilled water.

Silver azide should be stored under water in a conductive rubber container. This preparation will 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 szide 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 azide is precipitated on mercury fulminate, tetryl, etc., these substances are as efficient weight for weight at pure silver azide (Ref g). White silver azide is less affected by light than mercury or lead azide (Ref h). Long colorless crystals which explode on breaking are obtained from azmonium hydroxide.

Origin:

Silver azide was first prepared in 1890-1 by T. Curtius (Ber 23, 3032; Ber 24, 3344-5) by passing hydrazoic acid (HN_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 emmunition 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. Hinkenbach, "Silver Azide: An Initiator of Datonation," <u>Army</u> <u>Ordnance</u>, Vol 5, p. 824 (1925).

- (c) E. Do W. S. Colver, High Explosives, London and New York, p. 527.
- (d) A. Stettbacher, Spreng u. Schlesstoffe, Rescher, Zurich, p. 97 (1948).
- (e) A. Marshall, Explosives, 2nd Ed, Vol II, p. 767, London.
- (f) A. Stettbacher, Z ges Schless-Sprengstoffw 10, pp. 193-214 (1915).

69See footnote 1, page 10.

Silver Azide

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(g) F. Blechts, Chim et Ind Special No. 921-5 (June 1933); C. A. 28, 646.

(h) L. Wohler and W. Krupko, Berichte <u>46</u>, 2047-2050 (1913).

(i) F. G. Haverlak, Examination of 120/45 MM HE Shell, Italian (FMAM-464), PATR No. 1515, 10 April 1945.

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Part et a

| % | | 188 |
|-----------------------------------------------------------------|--------------------------------------|---------|
| | Mok wier Weight: (C2H8N100) | |
| C 12.8 | Oxygen Selanca: CO ₂ % | -60 |
| H 4.3 NH NH | ۵۵ % | -43 |
| C-NH-NH-N = N-C | Densily: gm/cc At 3000 pai | 1.05 |
| о 8.5 ^{ин} 2 ин-ин-ио | Melting Puint 'C Explodes | 140-160 |
| C/H Ratio 0.068 | Freezing Point: *C | |
| Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm ? | Sulling Point: *C | |
| Sample Wt 20 mg | Rafractiva Index, ng | |
| Picatinny Arsenal Apparatus, in.2; (8 oz. vt.) 8 | 102 | |
| Sample Wt, mg | 11 | |
| Friction Pendulum Toot: | Vecuum Stability Yest: | |
| Steel Shoe | cc/40 Hrs, at | |
| Fiber Shoe | 90°C | • |
| | - 100°C | |
| Rifle Bullet Impact Test: Triais | 120°C | |
| % Explosions | 135°C | |
| Portials | 150°C | |
| Burned | 200 Gram Bamb Sund Test: | |
| Unaffected | | 28.0 |
| | Sond, gm Black powder fuse 4.0 | |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cop used) | Minimum Detonating Charge, gm | . 1 |
| 1 5 160 | Mercury Fulminute | 0.40 |
| 10 | Lead Azide | |
| 15 | Tetryi | |
| 20 | Ballistic Mostar, % TNT: | |
| | - Tiouxi Test, % TNT: (a) | 61 |
| 75°C International Hoot Test: % Loss in 48 Hrs 0.5 | Plote Deat Test: Method | |
| 100°C Heet 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 | |
| Flemmebility Index: | - Detenation Rate: Confinement | |
| Hygrescepiekty: % 30°C, 90% Rit 0.77 | - Condition Charge Diameter, in. | |
| | Density, gm/cc | |

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Tetracene

AMCP 706-177

| Fregmentetion Test: | Sheped Charge Effectiveness, TNT = 100: |
|---------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: Density, gm/cc Charge Wt, Ib | Gloss Cones Steel Cones Hole Volume Hole Depth |
| Total No. of Fregments: For TNT For Subject HE 3 inch HE, M42A1 Projectile, Lot KC-5: Density, gm/cc Charge Wt, Ib | Color: Pale yellow Frincipal Uses: Priming compositions and detonators |
| Tetal No. of Fregments: For TNT For Subject HE | Mothed of Looding: Pressed |
| Fregment Velocity: ft/sec At 9 ft At 25½ ft Density, gm/cc Blast (Relative to TNT): | At 3000 pai 1.05 Sharege: Wet Mathind Wet Hazord Closs (Quantity-Diships) Class 9 |
| Air: Peak Pressure Impulse Energy | Compatibility Group Group N Exudetion |
| Air, Confined; Impulse Under Weter: Peak Pressure Impulse Energy Underground: Peak Pressure Impulse Energy | Solubility: Practically insoluble in water, alcohol, acetone, ether, benzene, carbontetrachloride or ethylenedichloride. Sensitivity to Electrostatic Discharge, Joules: Discharge, Joules: (b) Unconfined 0.010 Confined 0.012 Heat of: Explosion, cal/gm Explosion, cal/gm 658 Gas Volume, cc/gm 1190 Initiating Efficiency: Tetracene is not efficient in initiating high explosives. |

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AMCP 706-177

Tetracene

Preparation:

(Rinkenbach and Burton, Army Ordnance 12, 120 (1931)).

Tetracene is prepared by dissolving 5 gms of aminoguanidine dinitrate in 30 cc of water, cooling to 0° C and mixing with a solution of 2.5 gms of sodium mitrate in 15 cr of water. The temperature is maintained at about 10° 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 basker and adding water heated to 30° 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 <u>43</u>, 682) who also studied its chemical reactions and determined its structure (Hoffman et al, Ber <u>43</u>, 1087, 1866 (1910); Ber <u>44</u>, 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

(2) B. P. MacDougell, Methods of Physical Testing, OSRD Report No. 803, 11 August 1942.

L. C. Smith and E. G. Eyster, <u>Physical Testing of Explosives</u>, <u>Part III - Hiscellaneous</u> <u>Bensitivity Tests</u>; <u>Performance Test</u>, OSRD Report No. 5746, 27 December 1945.

(b) F. W. Brown, D. H. Rusler and F. C. Gibson, <u>Sensitivity of Explosives to Initiation</u> by Electrostatic Discharges, U. S. Dept of Int, Bureau of Kines, NJ 3552, 1946.

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

| <u>o</u> | 1 | 3 | <u>4</u> | I | <u>8</u> | 2 |
|----------|---|-----|--------------|-----|----------|-------------|
| 1450 | ц | 453 | 1104 2164 | 407 | 318 | 859 2179 |

70See footnote 1, page 10.

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Tetranitrocarbazole (TNC)

AMCP 706-177

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| Composition: | Molecular Weight: (C ₁₂ H ₅ N ₂ O ₈) 347 |
|------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| $^{\text{%}}$ $^{\text{O}_2\text{N}}$ H $^{\text{NO}_2}$ c 41.6 \checkmark $^{\text{N}}$ \checkmark | Oxygen Belance: |
| | CO, % -85 CO % -30 |
| | |
| N 20.0 ² " | Density: gm/cc |
| 0 37.0 | Melting Peint: °C Pure 1, 3, 6, 8-1 somer 296 |
| C/H Rotio 1.032 | Freezing Soint: "C |
| Import Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 100+ | Builing Point: *C |
| Sample Wt 20 mg | Refrective Index, no |
| Picatinny Arsenal Apparatus, in. 18 Sample Wt, ma 14 | 10 10 |
| Sumple Wit, ng 14 | nä |
| Friction Pandulum Test: | Vacuum Stability Test: |
| Steel Shoe Unaffected | cc/40 Hrs, at |
| Fiber Shoe Unaffected | 90°C |
| Rifle Bullet Impact Test: Trials | 100°C 0.2 |
| % | 120°C 0.2 |
| Explosions | 135°C |
| Partials | 150°C |
| Burned | 200 Gram Homb Sand Test: |
| Unoffected | Sand, gm 41.3 |
| Explosion Temperature: *C | Sensitivity in Initiation: |
| Seconds, 0.1 (no cop used) | Minimum Detonating Charge, gm |
| 1 | Mercury Fulminate |
| 5 Jacomposes 470 10 | Lead Axide 0.20 |
| 15 | Tetryi 0.25 |
| 20 | Bollistic Morter, % TNT: |
| | Trouil Test, % TNT: |
| 75°C Internetional Heat Yest; % Loss in 48 Hrs | Piete Dent Test: |
| | Method |
| 100°C Heat Test: | Condition |
| % Loss, ist 48 Hrs 0.15 | Confined |
| % Loss, 2nd 48 Hrs 0.05 | Density, gm/cc |
| Explosion in 100 Hrs None | Brisance, 96 TNT |
| | Detenation Rate: |
| Flammability Index: | Confinement Condition |
| Hygrescepicity: % 30°C, 90% RH 0.01 | Charge Diameter, in. |
| Vələtility: | Density, gm/cc |
| | Rote, meters/second |

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Tetranitrocarbazole (INC)

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| Freymontation Test: | Shoped Charge Effectiveness, TNT = 100: | | |
|---------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--|
| 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 Fregments: For TNT For Subject HE | Color: Principal Uses: Component of igniter and pyrotechnic compositions | | |
| 3 inch HE, (A42A1 Projectile, Let KC-5; Density, gm/cc Chargh Wt, ib | | | |
| Tetal No. of Fragments; For TNT For Subject HE | Method of Looding: | Pressed | |
| Programmi Velecity: ft/sec At 9 ft At 25% ft Density, gm/cc | Looding Dansity: gm/cc Storage: Method | Dry | |
| Sieut (Relative to YNY); Air: Peak Pressure Impulse Energy | Hazard Class (Quantity-Distance) Compatibility Group Exudation | Class 9 | |
| Air, Confined: Impulse Under Weter: Peck Pressure Impulse Energy Underground: Peok Pressure Impulse Energy | Solubility in Water, <u>gm/100 gm (%), at:</u> 95 ⁰ C <u>Qualitative Solubilities:</u> <u>Solvent</u> Nitrobenzene Acetone Nenzene Chloroform Carbontetrachlorids Ether Zther, petroleum | 0.10 Solubility Very soluble Soluble Insoluble Insoluble Insoluble Insoluble Insoluble | |
| | | | |

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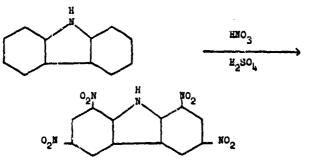
Tetranitrocarbasole (THC)

AMCP 706-177



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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 reising 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>Nitration:</u> The sulfonate solution is slowly added to 168 gas of HNO₃ (Plant grade specific gravity 1.525 at 15°C) maintaining the temperature at 30° to 50°C. (Time required - 1 hour 25 minutes). The temperature is then gradually reised to 70° to 75°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.

<u>Drowning:</u> The nitratica 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 said free.

Drying: The TNC is spread in a thin layer and dried at 100° to 110°C for four hours.

Yield: 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:

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The preparation of 'hetranitrocarbazole (INC) 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 42, 3600 1909)). However, G. L. Ciamician and P. P. Silber observed the formation of four isomeric TMC's when acetyl carbazole was treated with fuming nitric acid (Gazz chim ital 12, 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 464,538). The Casella process of

Tetranitrocarbazole (TNC)

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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-TNC (W. Borsche and B. G. B. Scholten Ber 50, 596 (1917) and about 10% of the 1,2,6,8-TNC isomer (D. B. Murphy et al J Am Chem Soc $\frac{75}{75}$, 4289 (1953). TNC 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 Merorandum Report No. 22, 2 September 1952.

(d) S. Livingston, Development of Improved Ignition Type Powders, PATR No. 2267, July 1956.

(e) Also see the following Picatinny Arsenal Technical Reports on Tetranitrocarbazole:

| <u>o</u> | 2 | 3 | <u>4</u> | I |
|----------|------|------|----------|--------------|
| 2180 | 1802 | 1973 | 1984 | 1647 1937 |

71see footnote 1, pege 10.

2,4,2',4'-Tetranitro-oxenilide (TNO)

AMCP 705-177

| Composition: % Q | 0 | Molecular Weight: (C14H8N6010) | 420 |
|---------------------------------------------------------------|-----------------|-----------------------------------|-----------------|
| % c 40.0 c | Į | Oxygen Belence: | |
| | Ĭ NH | CO. % CO % | -84 -31 |
| H 1.9 | NO2 NO2 | | <u>ير -</u> |
| N 20.0 | | Density: gm/cc | |
| 0 38.1 | \searrow | Melting Pelat: *C Decomposes | 313 |
| C/H Ratio 0.735 NO2 | NG ² | Freexing Point: *C | |
| Impect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | | Boiling Point: *C | |
| Sample Wt 20 mg Disationy Arroad Anagonitys in | 30 | Refrective Index, nm | |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | 30 11 | n <mark>o</mark> n | |
| | | n <mark>u</mark> , | |
| Friction Pendulum Test: | | Vocuum Stability Test: | |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | •• |
| Rifle Bullet Import Test: Trials | | 100°C | |
| % | | 120°C | 0.11 |
| Explosions | | 135°C | |
| Partials | | 150°C | |
| Surned | | 200 Grem Benth Sand Test: | |
| Unoffected | | Sond, gm | 16.3 |
| Explosion Tomperature: *C | | Sensitivity to initiation: | |
| Seconds, 0.1 (no cop used) | 1 | Minimum Detonating Charge, gm | |
| i 5 302 | | Mercury Fulminate | |
| 5 392 10 | | Lood Azide | 0.20 |
| 10 | | Tetryl | 0.25 |
| 75 20 | | Ballistic Mortar, % TNT: | |
| 4U | | Truuzi Test, % TNT: | |
| 75 °C International Heat Test: | | Plate Deat Test: | |
| % Loss in 48 Hrs | • · | Method | |
| 100°C Heat Yest: | | Condition | |
| % Loss, 1st 48 Hrs | 0.07 | Confined | |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisonce, % TNT | |
| Flammability Index: | | Detanetion Rate: Confinement | |
| Hygrescepicity: % 30°C, 90% FH | Trace | Condition Charge Diameter, in. | |
| Vəlati Hty: | | Density, gm/cc | |

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2,4,2',4'-Tetranitro-oxanilide (TNO)

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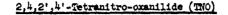
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| Fragmentation Test: | Shaped Charge Effectiveness, TNT = 1 | GO: |
|---------------------------------------------------------|--------------------------------------|-------------------------|
| 90 run HE, M71 Projectile, Let WC-91; Density, gm/cc | Glass Cones Steel (Hole Volume | Corries |
| Charge Wt, Ib | Hole Depth | |
| | | |
| Total No. of Fragments: | Color: Tdg | ht yellow |
| For TNT | | NC ARTON |
| For Subject HE | Principal Uses: Co-monent of black | k nowlen time |
| 3 Inch HE, M42A1 Projectile, Let KC-5: | ar pyrotechnic c | |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| | | |
| Total No. of Fragments: | Method of Looding: Pressed and | |
| For TNT For Subject HE | composition. | |
| | Lording Density; gm/cc | |
| Frequent Velocity: ft/sec | | |
| At 9 ft | | |
| At 251/2 it | Stereye: | |
| Density, gm/cc | Method | Dry |
| ······································ | | |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) | Claise 9 |
| Air: | Compatibility Group | |
| Peok Pressure | n | |
| Impulse | Exudation | |
| Energy | | |
| Ale, Continue: | Solubility, gu/100 cc Solvent, s |) |
| Impulse | | <u>°c</u> <u>\$</u> |
| Under Water: | Water | 100 40.10 |
| Peok Pressure - | Nitrobenzene | 150 >15 |
| Impulse | Qualitative Solubilities: | |
| Energy | Solvent | Solubility |
| Underground: | Ethyl elcohol Benzene | Insoluble |
| Peak Pressure | Butyl acetate | Insoluble Insoluble |
| Impulse | Carbontetrachloride | Insoluble |
| Energy | Ethyl ether Acetic acid | Incoluble Soluble |
| | Nitric and | Soluble |
| | Caustic potash Dimethyl formamide | Soluble Very soluble |
| | | |
| | | |
| | | |

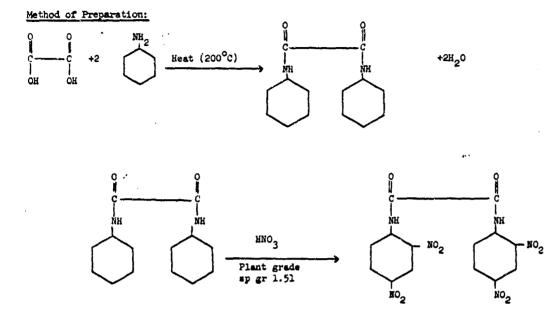
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 (b_{i})









Oxanilide:

Two parts of oxalic acid 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 effervescence. The mass is cooled to room temperature, poured into deveral volumes of water $(21^{\circ}-24^{\circ}C)$, filtered on a Büchner funnel and washed free of oxalic add with water and then washed free of actiline with acetone. The oxanilide is air dried to remove the acetone and then dried at 100°-110°C.

Tetranitro-cosmilide (TNO):

A 5 liter round bottom flask is equipped with a stirrer of a type which will produce a downward "swirl." The flask is surrounded with a water jacket for hot and cold water. Fifteen hundred grams (1.5 kilograms) of 98% plant grade nitric acid is placed into the flask. Five hundred (500) grams of commilde is slowly added to the acid under mapid agitation while the tem, rature is maintained below 40° C. After the addition of the commilde is completed $(2\frac{1}{2}-3$ http://, the agitation is continued 10-15 minutes. The temperature is then raised to 80° C over a period of one hour and maintained at $80^{\circ}-85^{\circ}$ C for 3 hours. The scid slurry is then cooled to room temperature and drowned by pouring over cracked ice. The filtered on a Ellaher funnel and washed with water until it is almost acid free. The filter cake is placed in a besker and sufficient water added to forms "slurry." Live batem is run into the "slurry" under agitation for 10 minutes. The slurry is fullered and the residue washed. The latter treatment of the "slurry" is repeated until the wash water is found to be neutral to

2,4,2',4'-Tetrauitro-oxanilide (TNO)

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lithus paper. The TNO is washed with alcohol, then acctone, air dried and finally dried at $100^9\text{-}110^9\text{C}\text{-}$

Yield = 90% to 97.5% of theoretical.

Origin:

 $\cdot y_{i}$

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A. G. Perkin in 1892 obtained tetranitro-examilide directly by heating a solution of finely powdered examilide in mitric acid. He also obtained the same compound by the action of a cooled mixture of mitric and sulfuric acids on examilide and precipitation the product by pouring the solution into water (J Chem Soc <u>61</u>, 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, <u>Substitution of Tetranitro Oxanilide and Hexanitro Cxanilide</u> for <u>Tetranitro Carbazole</u>, PA Fyrotechnic Research Laboratory Report 54-TF 1-38, 20 December 1954.

72See footnote 1, page 10.

| Composition: % # c-N | | Molecular Waight: (C7H5N508) | 287 |
|-------------------------------------------------------------------------------------------------------|-----------------------------------|------------------------------------|--------------|
| c 29.3 | -NO2 NO2 | Onygen Selence: CO, % CD % | -47 - 8 |
| H 1.7 0 ₂ N | T ¹⁰ 2 <i>y</i> | Densily: gm/cc Crystal | 1.73 |
| о щ.6 | 418.1 | Malting Point: *C | 130 |
| C/H Ratio 0.420 | D ₂ | Freezing Paint: "C | |
| Impact Sensitivity, 2 Kg Wt: | | Beiling Peint: *C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg Picc^inny Arsenal Apparatus, in. Sample Wt, mg | 26 8 18 | Refrective Index, ng ng ng | |
| Friction Pendulum Test: | | Vacuum Stability Test: | |
| Steel Shoe | Crackles | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifle Bullet Impoct Test, Trials | | - 100°C | 0.3 |
| % | | 120°C 135°C | 1.0 |
| Explosions 13 | | 150°C | |
| Partials 54 | | 130 C | |
| Burned 10 | | 200 Gram Bamb Send Tests | |
| Unoffected 23 | | Sand, gm | 54.2 |
| Explosion Temperature: *C | | Sensitivity to initiation: | |
| Seconds, 0.1 (no cap used) 340 | | Minimum Detonating Charge, gm | 0.20* |
| 1 314 5 Ignites 257 | | Mercury Fulminote Lood Azide | 0.10* |
| 10 238 | | | 0.10* |
| 15 236 | | *Alternative initiating charges. | |
| 20 234 | | Sollistic Martar, % THY: (a) | <u>,</u> 130 |
| | | Treasl Test, % TNT: (b) | 125 |
| 75°C International Hout Test: % Loss in 48 Hrs | 0.01 | l'Iste Dunit Test: (c) Method A | B |
| 100°C Heat Test: | | Condition Pressed | Pressed |
| % Loss, 1st 48 Hrs | 0.1 | Confined Yes | No |
| 95 Loss, 2nd 48 Hrs | 0.0 | | 59 1.36 |
| Explosion in 100 Hrs | None | Brisance, % TNT 11.6 13 | .5 96 |
| Flemmability Index: | 21/4 | - Detenction Rate: Confinement | None |
| | | Condition | Presse |
| Hygroscopicity: % 30°C, 90% RH | 0.04 | Charge Diameter, in. | 1.0 |
| Valetility: 25°C | 0.00 | Density, gm/cc | 1.71 |
| Valetility: 25°C | 0.00 | Rate, meters/second | 7850 |

Tetry1

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<u>Tetryl</u>

| lesster Sensitivity Test: Condition | (d) Pressed | Decomposition Equation: Oxygen, atoms/sec | (g) (h) 10 ^{15.4} 10 ^{12.9} |
|--------------------------------------------|----------------------------------------|----------------------------------------------|--------------------------------------------------|
| Condition Tétryi, gm | 100 | (Z/sec) | |
| Wax, in. for 50% Detonation | 2.01 | Hent, kilocalorie/mole | 38.4 34.9 |
| Wax, gm | | (AH, kcal/mol) Temperature Range, °C | 211-260 132-164 |
| | 1.58 | Phase | Liquid Liquid |
| Density, gm/cc | 1.70 | FILLE | |
| Heat of: | 2025 | Armer Plate Impost Test: | <u></u> |
| Combustion, cal/gm | 2925 1080-1130 | | |
| | 760 | 60 mm Morter Projectile: | |
| Gas Volume, cc/gm Examplian col/com | -14 | 50% Inert, Velocity, ft/ | Sec. |
| Formation, col/gm Fusion, col/gm (e) | 22.2 | Aluminum Fineness | |
| Fusion, cal/gm (e) Temperature, °C | 127 | 500-th General Purpose Be | minte |
| ipecific Heet: cal/gm/°C | (e) | Diete Thiskness Inchus | |
| -100 | 0.182 | Piate Thickness, inches | |
| - 50 | 0.200 | 1 | |
| 0 | 0.212 | 1% | • |
| 50 100 | 0.223 0.236 | 14 | |
| 200 | 0.230 | - 1% | |
| Burning Rate: | | | |
| cm/sec | | Bamb Drep Test: | |
| Thermal Conductivity: (1) | ······································ | | |
| col/sec/cm/*C 5.81 x 10 4 at | 1.394 gu/cc 1.528 gu/cc | 17, 2000-lb Sami-Armar-P | iercing Bomb vs Concrete: |
| Coefficient of Expension: | | Max Safe Drop, ft | |
| Linear, %/*C | | 500-ib Goversi Purpuse Be | imă ve Concrete: |
| Volume, %/*C | | Height, ft | |
| | ····· | Tricis | |
| Hardwess, Mohs' Scale: | | Unatfected | |
| | | - Low Order | |
| Young's Modulus; | | High Order | |
| E', dynus/cm² | , | | |
| E, Ib/inch ² | | 1000-lb Ganacai Purpose B | emb vs Concrete: |
| Density, gm/cc | | | |
| | المستعدية والمتحدين | | |
| Compressive Strengths ib/inch ^a | | Trials | |
| | | Unaffected | |
| Vapor Pressure: | | Low Order | |
| *C mm Mercury | | High Order | |
| | | | |
| | | | |
| | | 1 | |

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| Fregmantation Test; | - <u> </u> | Shaped | Churge | Effective | iness, Ti | NT = 100 | : | |
|----------------------------------------|------------|-------------------|------------------|------------------|------------|---------------------|--------------------|---------------------|
| 90 mm HE, M71 Projuctile, Lot WC-91: | | | | Glass C | ones | Steel Cor | 165 | |
| Density, gm/cc | 1.58 | Hole | Volume | | | | | |
| Charge Wt, Ib | 2.052 | Hole | Depth | | | | | |
| Total No. of Fragments: | | Coler: | <u>.</u> | | | Thebt | | |
| For TNT | 703 | Color: | | | | Light | Yellow | |
| For Subject HE | 864 | Principu | d Uses; | Boort | ters; { | ngreater | t of e | жр)т- |
| 3 inch HE, M42A1 Projectile, Let KC-3: | | | | | | es, det. | onators | . art |
| Density, gm/cc | 1.62 | | | DT881 | ting c | pa | | |
| Charge Wt, ib | 0.848 | | | | | | | |
| Total No. of Fragments: | | Method | | | | | Pres | |
| For TNT | 514 | | | nag : | | | Free | 54C |
| For Subject HE | 605 | l andina | Banala | | | | | |
| | | Localing | Dealerty | n gin/cc | | See held |)M | |
| Bregmont Velocity: ft/sec At 9 ft | | | | | | | | |
| At 251/2 ft | | Storage | 6 | | | | | |
| Density, gm/cc | | Meth | od | | | | Dr, | |
| Blast (Relative to TNT); | | Hara | rd Class | i (Quanti | ty-Dista | nce) | Clau | g (i) |
| Ain Peak Pressure | | Comp | atibility | Group | | | Grow | ə G |
| Impulse | | Exur | ation | | Doe | s not e | ude at | ى <mark>د</mark> ى: |
| Energy | | | | | | | | |
| Air, Confined: | | Logding | Densi | ty: gr | ¤∕ce | | | |
| impulse | | Cas | t 1.62 | Pro | besed | psi x : | 10 ³ | |
| Under Water; Peak Pressure | | 0.9 | 3 1,40 | 5 1.47 | 10 1.57 | 12 1.60 | 15 1.03 | 25 1. (7 |
| Impulse | | 0.9 | 1,40 | 7141 | ±+2(| 1.00 | 1.03 | L. C. C |
| Energy | | ļ | | | 30 1.71 | | | |
| Underground: Peak Pressure | | Effect Rate of | of lem Denon | peratu ntion: | re on | | (;;) | |
| Impulse | | 16 4 | rs at, | • | | e). | ^ | |
| Energy | | Dens | ity, g , m/ae | m/ce | | -54 1+52 7150 | 2 : . : 71 : | 53 |
| | | | | | | | | |

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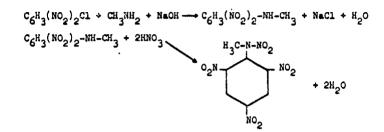
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Tetry1

Preparation:

(Manufacture of Tetryl by Dinitromonomethylaniline Process, Wannamaker Chemical Co., Inc.)



To a solution of 202.5 gm dinitrochlorbenzene in 200 cc benzene, at 75° C with good agitation, 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°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° 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°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°C, plus 48 minutes at 50° to 55°C at the end. The mixture is then cooled to 20°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°C with 500 cc water, filtered warm and then washed with water until the washings are neutral to methyl orange. The fatryl dried to constant weight at 70°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 80/1.8/18.2 sulfuric/nitric/water).

2. Nitration maximum temperature is 50°C.

3. The slurry is cooled to 35°C before filtration.

4. Filtration time prior to drowning, is minimized (15 minutes maximum).

The crude tetryl produced is recrystallized to remove impurities and occluded acid and to control its granulation.

| | nfined Nned | | 0.007 4.4 | | | | | | |
|----------------------------|-----------------------------------------------|----------------------|----------------------------------|--------------------------------|------------------|-----------------------------|----------------------------------|---------------------------------|-------------------------------------------------|
| olubility | of tetryl, | grame in 1 | 00 grams (%) | of: | | | | | |
| Wat | -0T | Carb | on tetrachlor | iđe | | Eth | er | <u>95</u> \$ | Alcohol |
| °c | ž | °c | | ź | | °c | ž | °C | ž |
| 0 20 40 80 100 | 0.0050 0.0075 0.0110 0.0810 0.184 | 0 04 09 | 0 | .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 | nroform | Carbon d | limulfide | Ethyl | ene dici | loride | | Acetone | |
| °c | ž | <u>°c</u> | ź | °c | | É | | 00 | を |
| 0 04 04 00 | 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 | | | 75 95 116 138 |
| Trichlo | roethylene | Ethyl ac | etate | | Benzene | | | Toluene | <u>.</u> |
| °c | L | °c | ž | oC | | X | | °C | Z |
| 0 08 08 08 08 | 0.07 0.12 C.26 0.67 1.50 1.76 | 80 | ~ 40 | 20 30 30 50 | | 7.8 10.0 12.5 16.0 | | 20 | 8.5 |
| | | X | ylene | | T | NT | | | |
| | | °c | £ | | °c | ž | | | |
| | | 20 30 40 50 | 3·3 · 4·4 5·4 6·0 | | 80 100 120 | 82 149 645 | | | |

Tetryl

Origin:

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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 chim <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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Tetryl

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Destruction by Chemical Decomposition:

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Tetryl is decomposed by dissolving in 12 times its weight of a solution prepared from 1. part by weight of sodium sulfite $(Na_2SO_3, 7H_2O)$ in 4 parts water. The sulfite solution may be heated to SO^{OC} to facilitate decomposition of the Tetryl.

references: 73

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

(b) Ph Naoum, 7 ges Schless---Sprengstoffw, pp. 181, 229, 267 (27 June 1932).

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

(d) 1. C. Smith and S. R. Welton, <u>A Consideration of RDX/Wax Mixtures as a Substitute for Tetrel in Poosters</u>, NOL Memo 10, 303; 15 June 1949.

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(f) E. Hutchinson, The Thermal Sersitiveness of Explosives. The Thermal Conductivity of Explosive Materials, AC 2861, First Report, August 1942.

(2) R. J. Finkelstein end G. Gamow, Theory of the Detonation Process, NAVORD Report No. - 30-46. 20 April 1947.

(h) M. A. Cook and M. T. Abegg, "Isothermal Decomposition of Explosives," University of Utsh. Ind Eng Chem 1090-1095 (June 1956).

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

(3) W. 1'. McGarry and T. W. Stevens, Detonation Rates of the More Important Military Explosives at Several Different Temperatures, PATR No. 2383, November 1986.

(k) Also see the following Picetinny Arsenal Technical Reports on Tetryl:

| <u>0</u> | 1 | 2 | 3 | <u>1</u> | ۶ | 6 | I | <u>8</u> | 2 |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| 30 600 770 510 1200 1300 1300 1300 1500 1500 1500 1500 | 11 361 381 622 861 1251 1251 1251 1251 1431 1651 | 132 582 982 1392 1392 1392 1392 1492 1492 | 453 493 623 833 863 1113 2053 2163 2233 | 84 144 294 314 674 7784 874 904 1134 1134 1234 2224 2204 | 65 195 565 635 845 1455 1285 1285 1285 1205 2105 | 266 556 786 986 1126 1316 1316 1416 1446 1556 1636 1956 | 117 197 637 707 807 857 1047 1137 1287 1337 1367 1437 1737 1797 1937 | 28 4 39 628 708 8 38 1418 1788 1828 1828 1838 | 129 179 319 609 709 849 999 1029 1209 1379 1429 1489 1819 1969 |

³See footnote 1, page 10.

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Tetrytol, 80/20

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| | 100.900. | | ARCE IVOI |
|-----------------------------------------------------|----------|----------------------------------|----------------------------|
| Composition: | | Melecular Weight: | 274 |
| 70 Tetryl | 80 | Oxygen Belence: | |
| 1401.11 | ~ | CO, % | -52 |
| TNT | 20 | CO % | -11 |
| | | Density: gm/cc Cast | 1.51 |
| | | Malting Paint: *C | 68 |
| C/H Ratio | | Freezing Point: *C | |
| Impact Sausitivity, 2 Kg Wt: | | Boiling Point: "C | |
| Bureau of Mines Apparatus, cm | 28 | Befunction Index _ D | |
| Sample Wt 20 mg Picatinny Arsenal Apparatus, in. | 9 | Refrective Index, no | |
| Sample Wt, mg | 17 | nSe | |
| | ~! | n | |
| Friction Pandulum Test: | | Vocuum Stability Test: | , |
| Steel Shoe | | cc/40 His, at | |
| Fiber Shoe | | 90°C | |
| | | 100"C | 3.0 |
| Rifle Bullet Impact Tuet: Trials | | 120°C | 11+ |
| ~ ~ | | 1 | *** |
| Explosions 0 | | 135°C | |
| Partials 20 | | 150°C | |
| Burned 0 | | 200 Grem Bumb Send Yest: | |
| Unoffected 80 | | Sand, gm | 54.0 |
| | | | |
| Explasion Temperature: *C | | Sensitivity to initiation: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm | |
| 1 | | Mercury Fulminate | 0.22* |
| 5 Ignites 290 | | Lead Azide | 0.17* |
| 10 | | "Alternative initiating charges. | |
| 15 | | | |
| 20 | | Ballietis Merier, % THT: | مر ما می است. مراجع است |
| 75°C International Heat Test: | | Trousl Test, % TNT: | |
| % Loss in 48 Hrs | | Plate Dant Tast: 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 | Brisonce, % TNT | |
| | | Dutenetien Refe: | |
| Fiermability Index: Will not continue | to burn | Confinement | |
| Munacessale bus Gl | 0.02 | Condition | |
| Hygrassapicity: % | | Charge Diameter, in. | |
| Volueility: | | Density, gm/cc | |
| | | Rate, metens/second | |

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| Fragmentation Test: | Shaped Charge Effectiveness, TNT = 10 | D: |
|---------------------------------------------------------------------------|---------------------------------------------------|-------------|
| 90 mm HE, M71 Projectile, Lot WC-91; Dansity, gm/cc Charge Wt, Ib | Glass Cones Steel Ca Hole Volume Hole Depth | nes |
| Tetal No. of Fragments: For TNT For Subject HE | Color: Light yel | low to buff |
| 3 Inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, Ib | Principal Uses: Bursters, demoliti | on blocks |
| Total No. of Fragmants: For TNT For Subject HE | Mothed of Looding: | |
| Fregment Velecity: ft/sec | Looding Kossity: gm/cc | |
| At 151% ft At 151% ft Density, gm/cc | Sterege: Method | Dry |
| Biast (Relative to TNT): | Mazard Class (Quaritity-Distance) | Class 9 |
| Airs Peak Pressure | Compatibility Group | Group I |
| Impulse Energy | Exuation Exuides | at 65°C |
| Air, Confined: Impulse | | |
| Under Weter: Peak Pressure | | |
| Impulse Energy | | |
| Undarground: Firak Pressure | | |
| impulse Energy | | |
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| Composition: | | Molecular Weight: | 270 |
|--------------------------------------------------------------|-----------------------------------------|---------------------------------|-------------------------------------------------------|
| | 75 | Oxygan Belence: | |
| Tetryl | 75 | CO ₂ % | - 54 |
| TNT | 25 | % 0.5 | -12 |
| | | Density: gm/cc Cast | 1.59 |
| | | Molting Points *C | 68 |
| C/H Ratio | | Freezing Point: *C | |
| mpact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 28 | Boling Point: *C | |
| Sample 14t 20 mg | 20 | Refractive Index, n" | |
| Picatinny Arsenal Apparatus, in. | 10 | nh | |
| Sample Wt, mg | 17 | n <u>o</u> | |
| Friction Pendulum Test: | | Vecuum Stability Tents | , an an del> |
| Steel Shoe | Cracks | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | • |
| | | | 3.0 |
| Rifie Buildt Impact Test: Trials | | 120°C | 11+ |
| % Explosions O | | 135°C | |
| | | 150°C | |
| Portials 30 Burned O | | | |
| | | 200 Grem Bamb Soud Yest: | |
| Unaffected 70 | | Sond, gin | 53.7 |
| Explosion Tempersities: *C | | Sancitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | | Missimum Detonating Charge, gm | |
| 1 | | Mercury Falminate | 0.23* |
| 5 Ignites 310 |) | Leod Azide | 0.19# |
| 10 | | *Alternative initiating charges | |
| 15 | | Ballistiz Mariar, % TNT: (a) | 122 |
| 20 | | | 166 |
| 75°C International Heat Tast: | | Truck Test, Si TNT: | |
| % Loss in 48 Hrs | | Finte Deat Test: (b) | |
| | | Method B | B |
| 100 °C Mout Yest: | | Condition Cast | Cast |
| % Loss, 1st 48 Hrs | | Confined No | Yes |
| 96 Loss, 2nd 48 Hrs | | Density, gm/ce 1.66 | 1.62 |
| Explosion in 100 Hrs | | Brisonce, & TNT 138 | 114 |
| Flammen 52012 Andrew trett to make and | | | |
| Finance billy index: Will not cor | iting to curn | Confinement | None |
| Hygrescepisity: % | 0.03 | Condition | Cast |
| | 0.03 | Charge Diamster, in | 1.0 |
| Ve Alliey: | يواليهية الجد الذال ويكار جاعد استخبارا | Density, gm/cc | 1.60 |
| | | Rote, meters/second | 7385 |

MAN BARRAR

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Tetryto?, 75/25

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| Frequentation Text: | | Shaped Charge Effectiveness, TNT == | 100: |
|------------------------------------------|-------|-----------------------------------------------|----------------|
| 90 mm HE, M71 Projectile, Lot W | C-91: | Glass Cones Steel | Cones (đ) |
| Density, gm/cc | 1.59 | Hole Volume 127 | |
| Charge Wt, Ib | 2.101 | Hole Depth 120 | |
| Total No. of Frequents: | | Celer: Light yell | lov to buff |
| For TNT | 703 | ingit yer | |
| For Subject HE | 857 | Principal Uses: Bursters, demold | tion blocks |
| 3 inch HE, M42A1 Projectile, Lot N | | | |
| Density, gm/cc | 1.60 | | |
| Charge W*, ib | 0.845 | | |
| Total No. of Fragmania: | | Method of Londing: | Cast |
| For TNT | 514 | | |
| For Subject HE | 591 | Looding Density: gm/cc | 1.59 |
| sugment Velocity: ft/sec | | | |
| A:9 ft At 25½ ft | | Storoge: | |
| Density, gm/cc | | Method | Dry |
| Blast (Relative to TNT): | | Hozord Class (Quantity-Distance) | Class 9 |
| به الله الله الله الله الله الله الله ال | | Compatibility Group | Group I |
| Peak Pressure | | | |
| Impulse | | Exudation | Exudes at 65°C |
| Unergy | | | |
| Alr, Coulland: | | Eutechic Temperature, °C: | 67.5 |
| lvopulse | | gm Tetry1/100 gm TNT 67.5°C | 54-82 |
| Under Water: Peak Prossure | | Booster Sensitivity Test: | (c) |
| Impulse | | | Cast |
| Energy | | Condition Tetryl, gm | 100 1.66 |
| Underground: Peak Pressure | | Wex, in. for 50% Detonation Dens'ty, gm/cc | 1.66 |
| Impulse | | | |
| Energy | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Provide a second second

Tetrytol, 70/30

AMCP 706-177

| Composition: % | | Melecular Weight: | 266 |
|----------------------------------------------------------------------------|---------------------------------------------------|----------------------------------|------------|
| Tetryl | 70 | Oxygen Balence: | |
| 10 | 10 | | -55 -13 |
| INT | 30 | CO % | -13 |
| | | Density: gm/cc Cast | 1.60 |
| | | Melting Point: *C | 68 |
| C/H Ratio | | Freezing Points *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 28 | Boiling Point: "C | |
| Sample Wt 20 mg | | Refrective Index, no | |
| Picatinny Amenal Apparatus, in. Sample Wt, mg | 11 18 | nS | |
| Jonple m, mg | | n _M | |
| Friction Pendulum Test: | | Vacuum Stability Test: | ······ |
| Steel Shoe | Unsffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifie Bullet Impact Test: Triais | | - 100°C | 3.2 |
| • | | 120°C | 11+ |
| % Explosions O | | 135°C | |
| Partialu 55 | | 150°C | |
| Burned 0 | | 200 Green Bernh Sand Test: | |
| Unaffected 45 | | Sand, gm | 53.2 |
| Explosion Temperature: *C | | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cop used) 41 | 6 | Minimum Detonating Charge, gm | |
| 1 38 | 7 | Mercury Fulminate | 0.23* |
| 5 Ignites 32 | | Loud Azide | 0.22* |
| 10 30 | | "Alternative initiating charges. | |
| 15 28 | • | | 120 |
| 20 27 | 5 | | 120 |
| 75°C International Heat Test: | | Plute Dout Test: (b) | ···· |
| % Loss in 48 His | | Method | в |
| | | Condition | Cast |
| 100°C Heet Test: | | Contined | Yes |
| % Loss, 1st 48 Hrs | 0.1 | Density, gm/cs | 1.60 |
| % Loss, 2nd 48 Hrs | 0.1 | Brisonce, % TNT | 117 |
| Explosion in 100 Hrs | None | | |
| Fiemmebility Index: Will not a | ontinue to burn | Confinement | Kona |
| | | Condition | Cast |
| Hygrascopicity: % | 0.02 | Charge Diameter, in. | 1.0 |
| | ومعروبين وبريان والمترجب والمترجب والمترجب والمتر | | 1.60 |
| Veletility: | | Density, gm/cc | 7340 |
| - | | Rate, meters/second | 1,040 |

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Server 2, Miller Miller Silver

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AMCP 706-177

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Tetrytol. 70/30

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| Fragmentation Test: | | Shaped Charge Effectiveness, $TNT = 100$: | |
|----------------------------------------|-----------------------------------------|--------------------------------------------|----------|
| 90 mm HE, M71 Projectile, Lot WC-91: | | Glass Cones Steel Cones | |
| Density, gm/cc | 1.60 , | iole Voluma | |
| Charge Wt, Ib | 2.090 | Hole Depth | |
| Total No. of Fragments: | | Color: Light yellow | |
| For TNT | 703 | Com: Englist yerrow | W UUII |
| For Subject HE | 840 | Principal Uses: Bursters, demolition | blocks |
| 3 inch HE, M42A1 Projectile, Let KC-5: | | | |
| Density, gm/cc | 1.60 | | } |
| Charge Wt, Ib | 0.842 | | |
| Total No. of Fragments: | | Method of Londing: | Cast |
| For TNT | 514 | | V==V |
| For Subject HE | 585 | Leeding Densky: gm/cc | 1.60 |
| Fregment Velecity: ft/sec At 9 ft | | · | |
| At 251/2 ft | | Storuga: | ł |
| Density, gm/cc | | Method | Dry |
| Blast (Relative to TNT): | *************************************** | Hazard Class (Quantity-Distance) | Class 9. |
| Airs | | Compatibility Group | Group I |
| Peak Pressure | | Exudation Exudes | at 65°0 |
| Impulse | | | |
| Energy | | | |
| Air, Confixed: Impulse | | | |
| Under Water: Peak Pressure | | | |
| Impulse | | | 1 |
| Energy | | | |
| Underground: Peak Pressure | | | |
| impulse | | 1 | 1 |
| Energy | | | |
| | | | |
| | | | |
| | | | _ |

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Tetrytol, 65/35

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| Composition: | | Molocular Weight: | 264 |
|---------------------------------------------------|---------------|----------------------------------|------------|
| | 65 | Oxygen Belence: | _ |
| Tetryl | 0) | CO, % CO % | -56 -14 |
| TIT | 35 | Density: gm/cc | 1.60 |
| | | Molting Point: *C | 68 |
| C/H Ratio | | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: | | Seiling Point: *C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg | 28 | | |
| Picatinny Arsenal Apparatus, in. | 11 | Refractive Index, RB | |
| Sumple Wt, mg | 17 | n2 | |
| | | n | |
| Friction Pendulum Test: | | Vocuum Stability Test: | |
| Steel Shoe | Cracks | cc/40 Hrs, at 90°C | |
| Fiber Shoe | Unaffected | - 100°C | 2.8 |
| Rifie Builet Impact Test: Trials | | 120°C | 11+ |
| % | | 135°C | *** |
| Explosions 0 | | 150°C | |
| Partials 10 | | | ····· |
| Burned O | | 200 Grein Bomb Sand Teso: | _ |
| Unoffected 90 | | Sand, gm | 52.6 |
| E.plosion Temperature: *C | | Sansitivity to Ini lon: | |
| Seconds, 0.1 (no cop used) | | Minimum Detonating Charge, gm | * |
| i 5 Ignites 325 | i | arcury Fulminate | 0.23* |
| 10 | | Leod Azide | 0.23* |
| 15 | | #Alternative initiating charges. | ····· |
| 20 | | Ballietic Mortar, % 7NT: | |
| | | Treuzi Test, % TNT: | • |
| 75°C Internetional Heat Test: % Loss in 48 Hrs | | Plata Dant Test: | |
| 70 COS IN 40 / ITS | | Method | |
| 100°C Heat 7est: | | Condition | |
| % Loss, 1st 4" Hrs | | Confined | |
| % Loss, 2nd 48 Hrs | | Density, gm/cc | |
| Explosion in 100 Hrs | | Brisance, % TNT | |
| | | Detenation Rate: | |
| Flammability Index: Will not con | tinue to burn | Crafinement | None |
| Hygrescopicity: % | 0.02 | - Condition | Cast |
| ······································ | | Charge Diameter, In. | 1.0 |
| Veletility: | | Density, gm/cc | 1.60 |
| ······································ | | Rate, meters/second | 7310 |

Tetrytol, 65/35

| Frequentation Test: | | Sheped Charge Effectivaness, TNY == | |
|------------------------------------------------------|----------------------------------------|-------------------------------------|-----------------------|
| | ۹. | (d) (e Giass Cones Steel |) Cones |
| 90 mm HE, M71 Prejectile, Lot WC-9 Density, gm/cc | 1.61 | | 26 |
| Charge Wt, Ib | 2.010 | | 19 |
| Total No. of Fragments: | | | |
| For TNT | 703 | Color: Light yello | w to buff |
| For Subject HE | 856 | | سيبيتيني معربيني ويست |
| 3 inch HE, M42A1 Projectile, Lot KC-: | 5. | Principal Usos: Bursters, demoli | tion blocks |
| Density, gn/cc | 1.60 | | |
| Charge Wt, Ib | 0.845 | | |
| Tatal No. of Fragmonts: | | | |
| For TNT | 514 | Method of Loeding: | Cast |
| For Su ⁴ ject HE | 585 | Looding Density: gm/cc | 1.60 |
| Fregment Velocity: ft/sec | ······································ | | 2100 |
| At 9 ft At 25½ ft | | Storege: | ····· |
| Dansity, gm/cc | | Method | Dry |
| Blact (Relative to TNT): | | Hazard Class (Quantity-Distance) | C1868 9 |
| Ain | | Compatibility Group | Group I |
| Peak Pressure | | | 0 |
| Impulse | | Exudation Exc | udes at 65°C |
| Energy | | | |
| Air, Confined: Impulse | | | |
| Under Water: Peak Pressure | | | |
| Impulse | | | |
| Energy | | | |
| Underground: Peak Pressure | | | |
| Impulse | | ₽ s | |
| Energy | | | |
| | | | |
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Tetrytol, 80/20, 75/25, 70/30, 65/35

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AMCP 706-177

Compatibility with Metals:

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

<u>Wet:</u> Stainless steel and mild steel coated with acid-proof black paint are unaffected. Copper, brass, aluminum, magnesium, magnesium-aluminum alloy, mild steel and wild steel plated with cadmium, copper, zinc or nickel are slightly affected.

Preparation:

Tetrytols are manufactured by heating TNT in a melting kettle, equipped with a stirrer, until all the TNT is melted. The necessary amount of herryl is added and heating and stirring are continued. The temperature is allowed to drop from 100° C until the mixture is of maximum viscosity suitable for pouring. Part of the tetryl dissolves in TNT forming a eutectic mixture which contains 55 percent tetryl. This mixture freezes at 67.5° C.

Origin:

4

Tetrytols were developed during World War II. The 70/30 tetryl/INT castable mixture is the most important in military applications.

References: 74

(a) L. C. Smith and E. G. Eyster, Physical Testing of Explosives, Part III, Miscellanous 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 1962.

(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) Eastern Labora'cry, du Pont, <u>Investigation of Cavity Effect</u>, Sec III, Variation of Cavity Effect with Explosive Composition, NDRC Contract W6/2-ORD-5723.

(e) Eastern Laboratory, du Pont, <u>Investigation of Cavity Effect</u>, Final Seport, Eastern Lab, du Pont, 18 September 1943, NDRC Contract W-672-ORD-5723.

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

| <u>0</u> | <u>1</u> | 2 | 3 | 2 | 6 | <u>7</u> | <u>8</u> | 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 1838 | 1379 |

⁷⁴See footnote 1, page 10,

AMCP 705-177

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調整

TNT (Trinitrotoluene)

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| Composition: % | | Melecular Weight: (C | 7 ^H 5 ^N 3 ^O 6 | ;) | 227 |
|-------------------------------------------------------------------------------------------------------|------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------------|-------------|---------------------------|
| с 37.0 сн _з | | Oxygen Balance: CO, % CO % | | | -74 -25 |
| N 18.5 | -NO2 | Density: gm/cc | Crysta] | - <u></u> | 1.65 |
| 0 42.3 | | Melting Paint: "C | | | 81 |
| C/H Rotio 0.549 NO | 2 | Freezing Points *C | | ******* | |
| Impact Sansitivity, 2 Kg Wts | | Bailing Paint: *C | | , | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg | 95-100+ 14-15 17 | Refractive Index, n ^D | | a B T | 1.5430 1.6742 1.717 |
| | sffected sffected | Vecuum Stability Test: cc/40 Hrs, at 90°C | | | |
| Rifle Builet Impact Test: Trials | ***** | - 100°C | | | 0.10 0.23 |
| * | | 135°C | | | 0.44 |
| Explosions . 4 | | 150*C | | | 0.65 |
| Partials O | | | | | |
| Burned O Unaffected G | | 200 Gram Komb Sand Yo Sand, gm | aat : | | 48.0 |
| Explosion Yemperature: *C Seconds, 0.1 (no cop used) 570 1 520 5 Decomposes 475 10 465 | | Sensitivity to Initiation; Minimum Detonating Mercury Fulminate Lead Axide *Alternative_initi | • | | 0.24# 0.27# |
| 15 | | | | | 1=100 |
| 20 | | Ballistic Mortar, % TN Trauxi Test, % TNT: | • <u> </u> | | i=100 |
| 75°C International Heat Tast: % Loss in 48 Hrs | 0.04 | Plate Dent Yest; Method | A | (a) A | <u> </u> |
| 100°C Heat Test: | | Condition | Cest | Pressed | Cast |
| % Loss, 1st 48 Hrs | 0.2 | Confined | Yes | Yes | No |
| % Loss, 2nd 48 Hrs | 0.2 | Density, gm/cc | 1.61 | 1.50 | 1.61 |
| Explosion in 100 Hrs | Nene | Brisance, % TNT | 1.00 | 100 | 100 |
| Fienimability Index: (b) | 100 | Detenation Rotes Confinement | | onfined | Unconfin |
| Hygrascopicity: % 30°C, 90% RH | 0.03 | | | 1854û | Cast 1.0 |
| Veletility: 30°C | N11 | - Density, gm/cc | 1.9 | 6 | 1.56 |

TNT (Trinitrotoluene)

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| Boostar Sonsitivity Test: | (c) | | Decomposition Equation: | (h), | (1) |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Condition | Pressed | Crat | Oxygen, atoms/sec | (h) 10 ^{11.4} | (1) $10^{12.2}$ |
| Tetryl, gm | 100 | 100 | (Z/sec) | | |
| Wax, in. for 50% De | tonation 1.68 | 0.82 | Heat, kilocolorie/mole (ΔH, kcol/mol) | 34.4 | 43.4 |
| Wax, gm | | | Temperature Range, *C | 275-310 | 238-277 |
| Density, gm/cc | 1.55 | 1.60 | Phose | Liquid | Liquid |
| Heut of: | (â) | | Armer Plate Impact Test: | | |
| Combustion, col/gm | | 3620 | Animer Field Impact Fest. | | |
| Explosion, cal/gm | | 1080 | 60 mm Mortar Projectile; | | (5) |
| Gas Volume, cc/g | m | 730 | 50% Inert, Velocity, ft | | >1100 |
| Formation, cal/gm | | 78.5 | Aluminum Fineness | | |
| Fusion, cal/am Tamperature, °C | | 22.34 79 | 500-ib General Purpose B | nan ha i | (٤) |
| English Master and Jam / | • | | | | (57 |
| Specific Heat: col/gm/ | - | 0.000 | Plate Thickness, inches | Trials | 🖇 Inert |
| 20 | | 0.309 0.328 | | • | |
| 50 | | 0.353 | 1 | 0 | |
| 80 | | 0.374 | 154 | 0 | |
| | | | 11/2 | 14 1 | 100 |
| Burning Rate: | | | - 131 | ţ, | 50 |
| cm/sec | | | Bomb Drop Test: | | |
| Thermel Conductivity: cal/set/cm/*C | See next p | ese. | T7, 2000-16 Semi-Armer-i | Piercing Bamb | vs Concrete: |
| Coefficient of Expansion | (>) | | Max Safe Drop, ft | 50 | 00-6000 |
| Peaticiant at wybousids | •; (b) | _ | | | |
| Linear, %/ C -40 | | | 500-lli Ganarci Purposa I | No Seal | |
| Linear, %/*C -40 ⁰ -40 ⁰ Volume, %/*C 27 ⁰ | to 60°C 5.4 3 to 60°C 6.7 3 to 80°C 16 x | (10 ⁻⁵ (b) | 500-H) General Purpose I Height, ft | | ete: |
| Linear, %/*C -40 ⁰ -40 ⁰ Volume, %/*C 27 ⁰ | to 60°C 5.4 3 | (10 ⁻⁵ (b) | | No Seal | ete: Seal |
| Linear, %/*C _40° _40° Volume, %/*C 27° 16° | to 60°C 5.4 3 to 60°C 6.7 5 to 80°C 16 x to 70°C 26.3 | (10 ⁻⁵) 10 ⁻⁵ (b) | Height, ft | No Seal 4,000 | ete: <u>Seal</u> 4-5,000 |
| Linear, %/*C _40° _40° Volume, %/*C 27° 16° Herdness, Mahs' Scele; | to $60^{\circ}C$ 5.4 s to $60^{\circ}C$ 6.7 s to $80^{\circ}C$ 16 x to $70^{\circ}C$ 26.3 (e) | (10^{-5}) 10^{-5} (b) x_10^{-5} (r.) | Height, ft Trials | <u>No Seal</u> 4,000 26 | ete: <u>Seal</u> 4-5,000 20 |
| Linear, %/*C _LC _L00 Volume, %/*C 270 160 Hardness, Mahs' Scale: Yeung's Medulus: | to 60°C 5.4 3 to 60°C 6.7 5 to 80°C 16 x to 70°C 26.3 | (10^{-5}) 10^{-5} (b) $x \cdot 10^{-5}$ (n) 1.4 | Height, ft Trials Unaffected Low Order | <u>No Sea1</u> 4,000 26 24 | ete: <u>Seal</u> 4-5,000 20 20 |
| Linear, %/*C _LC _L00 Volume, %/*C 270 160 Hardness, Mahs' Scale: Young's Modulus: E', dynes/cm ² | $\begin{array}{c} to \ 60^{\circ}C \ 5.4 \\ to \ 60^{\circ}C \ 6.7 \\ to \ 80^{\circ}C \ 16 \\ to \ 70^{\circ}C \ 26.3 \\ \hline \end{array}$ | (10^{-5}) 10^{-5} (b) $\times 10^{-5}$ (n) 1.4 5.45×10^{10} | Height, ft Trials Unaffected | <u>No Ses1</u> 4,000 26 24 2 | ete: <u>Seal</u> 4-5,000 20 20 0 |
| Linear, %/*C _LC _L00 Volume, %/*C 270 160 Hardness, Mahs' Scale: Yeung's Medulus: | $\begin{array}{c} to \ 60^{\circ}C \ 5.4 \\ to \ 60^{\circ}C \ 6.7 \\ to \ 80^{\circ}C \ 16 \\ to \ 70^{\circ}C \ 26.3 \\ \hline \end{array}$ | (10^{-5}) 10^{-5} (b) $\times 10^{-5}$ (n) 1.4 5.45×10^{10} 0.79×10^{6} | Height, ft Trials Unaffected Low Order | <u>No Ses1</u> 4,000 26 24 2 0 | ete: <u>Seal</u> 4-5,000 20 0 0 |
| Linear, %/*C _LC _L00 Volume, %/*C 270 160 Hardness, Mahs' Scale: Young's Modulus: E', dynes/cm ² | $\begin{array}{c} to \ 60^{\circ}C \ 5.4 \\ to \ 60^{\circ}C \ 6.7 \\ to \ 80^{\circ}C \ 16 \\ to \ 70^{\circ}C \ 26.3 \\ \hline \end{array}$ | (10^{-5}) 10^{-5} (b) $\times 10^{-5}$ (n) 1.4 5.45×10^{10} | Height, ft Trials Unaffected Low Order High Order | <u>No Ses1</u> 4,000 26 24 2 0 Bomb vs Concr <u>No Ses1</u> | ete: <u>Seal</u> 4-5,000 20 20 0 0 0 |
| Linear, %/*CLC L00 Volume, %/*C 270 160 Herdness, Mehs' Scale: Young's Modulus: E', dynes/cm ² E, lb/inch ² Density, gm/cc | to $60^{\circ}C$ 5.4 s to $60^{\circ}C$ 6.7 s to $80^{\circ}C$ 16 x to $70^{\circ}C$ 26.3 (e) (b) | (10^{-5}) 10^{-5} (b) $\times 10^{-5}$ (n) 1.4 5.45×10^{10} 0.79×10^{6} 161 | Height, ft Trials Unaffected Low Order High Order | <u>No Ses1</u> 4,000 26 24 2 0 Bomb vs Conce | ete: <u>Sea1</u> 4-5,000 20 20 0 0 |
| Linear, %/*C =4C =40 ⁰ Volume, %/*C 27 ⁰ 16 ⁰ Hardness, Mahs' Scale: Yeung's Modulus: E', dynes/cm ² E, lb/inch ² Density, gm/cc Compressive Strength: 1 | to $60^{\circ}C$ 5.4 s to $60^{\circ}C$ 6.7 s to $80^{\circ}C$ 16 x to $70^{\circ}C$ 26.3 (e) (b) | (10^{-5}) (b) $x 10^{-5}$ (b) $x 10^{-5}$ (n) 1.4 5.45×10^{10} 0.79×10^{6} 161 ∞ -14000 | Height, ft Trials Unaffected Low Order High Order 1000-Ib General Purpose | <u>No Ses1</u> 4,000 26 24 2 0 Bomb vs Concr <u>No Ses1</u> | ete: <u>Seal</u> 1-5,000 20 20 0 0 ete: <u>Seal</u> 5,000 26 |
| Linear, %/*C _LC _L00 Volume, %/*C 270 160 Herdness, Mehs' Scele: Yeung's Medulus: E', dynes/cm ² E, lb/inch ² | to $60^{\circ}C$ 5.4 s to $60^{\circ}C$ 6.7 s to $80^{\circ}C$ 16 x to $70^{\circ}C$ 26.3 (e) (b) | (10^{-5}) 10^{-5} (b) $\times 10^{-5}$ (n) 1.4 5.45×10^{10} 0.79×10^{6} 161 | Height, ft Trials Unaffected Low Order High Order 1000-Ib General Purpose Height, ft | <u>No Ses1</u> 4,000 26 24 2 0 Bomb vs Concr <u>No Ses1</u> 5,000 | ete: <u>Seal</u> 4-5,000 20 0 0 ete: <u>Seal</u> 5,000 |
| Linear, %/*C =4C =40 ⁰ Volume, %/*C 27 ⁰ 16 ⁰ Hardness, Mahs' Scale: Yeung's Modulus: E', dynes/cm ² E, lb/inch ² Density, gm/cc Compressive Strength: 1 | to $60^{\circ}C$ 5.4 s to $60^{\circ}C$ 6.7 s to $80^{\circ}C$ 16 x to $70^{\circ}C$ 26.3 (e) (b) | (10^{-5}) (b) $x 10^{-5}$ (b) $x 10^{-5}$ (n) 1.4 5.45 x 10 ¹⁰ 0.79 x 10 ⁶ 161 x - 14000 1.62 | Height, ft Trials Unoffected Low Order High Order 1000-Ib General Purpose Height, ft Trials | <u>No See1</u> 4,000 26 24 2 0 Bomb vs Concr <u>No See1</u> 5,000 21 | ete: <u>Seal</u> 1-5,000 20 20 0 0 ete: <u>Seal</u> 5,000 26 |
| Linear, %/*C -4C -60 Volume, %/*C 27 16 Herdness, Mehs' Scale: Young's Medulus: E', dynes/cm ² E, lb/inch ² Density, gm/cc Compressive Strength: I Density, gm/cc Veper Pressure: *C | to 60°C 5.4 5 to 60°C 6.7 5 to 80°C 16 x to 70°C 26.3 (e) (b) b/inch ² 1380 | (10^{-5}) (b) $x 10^{-5}$ (b) $x 10^{-5}$ (n) 1.4 5.45×10^{10} 0.79×10^{6} 161 ∞ -14000 | Height, ft Trials Unoffected Low Order High Order 1000-15 General Purpose I Height, ft Trials Unaffected | <u>No Sea1</u> 4,000 26 24 2 0 Bamb vs Concr <u>No Sea1</u> 5,000 21 18 | ete: <u>Seal</u> 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| Linear, %/*C -4C -L0 ⁰ Volume, %/*C 27 ⁰ 16 ⁰ Herdness, Mehs' Scale: Young's Medulus: E', dynes/cm ² E, lb/inch ² Density, gm/cc Compressive Strength: I Density, gm/cc Veper Pressure: *C 80 | to 60°C 5.4 3 to 60°C 6.7 3 to 80°C 16 x to 70°C 26.3 (e) (b) b/inch ² 1380 | (10^{-5}) (b) $x 10^{-5}$ (b) $x 10^{-5}$ (n) 1.4 5.45 x 10 ¹⁰ 0.79 x 10 ⁶ 161 x - 14000 1.62 | Height, ft Trials Unoffected Low Order High Order 1000-15 General Purpose 1 Height, ft Trials Unoffected Low Order | <u>No Sea1</u> 4,000 26 24 2 0 Bamb vs Concr <u>No Sea1</u> 5,000 21 18 0 | ete: <u>Seal</u> 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| Linear, %/*C -40° -40° Volume, %/*C 27° 16° Hardness, Mahs' Scale: Yeung's Modulus: E', dynes/cm ² E, lb/inch ² Density, gm/cc Compressive Strength: 1 Density, gm/cc Veper Pressure: *C 80 85 | to 60°C 5.4 5 to 60°C 6.7 5 to 80°C 16 x to 70°C 26.3 (e) (b) b/inch ² 1380 mm Mercury 0.042 0.053 | (10^{-5}) (b) $x 10^{-5}$ (b) $x 10^{-5}$ (n) 1.4 5.45 x 10 ¹⁰ 0.79 x 10 ⁶ 161 x - 14000 1.62 | Height, ft Trials Unoffected Low Order High Order 1000-15 General Purpose 1 Height, ft Trials Unoffected Low Order | <u>No Sea1</u> 4,000 26 24 2 0 Bamb vs Concr <u>No Sea1</u> 5,000 21 18 0 | ete: <u>Seal</u> 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0 |
| Linear, %/*C -4C -L0 ⁰ Volume, %/*C 27 ⁰ 16 ⁰ Herdness, Mehs' Scale: Young's Medulus: E', dynes/cm ² E, lb/inch ² Density, gm/cc Compressive Strength: I Density, gm/cc Veper Pressure: *C 80 | to 60°C 5.4 3 to 60°C 6.7 3 to 80°C 16 x to 70°C 26.3 (e) (b) b/inch ² 1380 | (10^{-5}) (b) $x 10^{-5}$ (b) $x 10^{-5}$ (n) 1.4 5.45 x 10 ¹⁰ 0.79 x 10 ⁶ 161 x - 14000 1.62 | Height, ft Trials Unoffected Low Order High Order 1000-15 General Purpose 1 Height, ft Trials Unoffected Low Order | <u>No Sea1</u> 4,000 26 24 2 0 Bamb vs Concr <u>No Sea1</u> 5,000 21 18 0 | ete: <u>Seal</u> 4-5,000 20 20 0 0 0 0 0 0 0 0 0 0 0 0 0 |

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INT (Trinitrotoluene)

| 90 mm HE, M71 Prejectile, Let WC-91: Gloss Cones Steel Cones Density, gm/cc 1.60 Hole Volume 100 100 Total Ne. ef Fregmente: For TNT 703 Calor: Light yellow For Subject HE 703 Principel Use: GP boxbs, H2 projectiles, det KC-5: Density, gm/cc 1.60 Obsection Principel Use: GP boxbs, H2 projectiles, det KC-5: Density, gm/cc 1.60 Obsection Generation Generation For Subject HE 514 Principel Use: Generation Generation For Subject HE 514 Sterage: Generation Generation For Subject HE 514 Leading Density: gm/cc See bulow Fregment Velocity: fr/sec 600 Art 2. Pressed Ornsity, gm/cc 1.58 Mathed of Leading: 1. Cast Air: Head Pressure 100 Inou Generation Impulse 100 Inou Generation Inou Impulse 100 Inou See Julow Inou Air: Head Pressure 100 Inou <th>Fragmentation Test:</th> <th></th> <th>Shaped Charge Effectiveness, $TNT = 100$:</th> | Fragmentation Test: | | Shaped Charge Effectiveness, $TNT = 100$: | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|-------|-----------------------------------------------------------------------|--|--|
| Charge Wr, Ib2.104Hole Depth100100Total No. of Fregments: For TNTT03 For Subject HET03Celer:Light yellow3 lack HE, M42A1 Projectile, Ler KC-5: Densirv, gm/cc1.60Principal Uses: demolition charges, depth charges, grenades, propellant compositions3 lack HE, M42A1 Projectile, Ler KC-5: Densirv, gm/ccMathed of Loading: 2.0848 I. Cast 2.0948 Total No. of Fregment: For Subject HESil4Mathed of Loading: 2.09488 I. Cast 2.094888 Total No. of Fregment: For Subject HESil4Mathed of Loading: $2.095888888888888888888888888888888888888$ | 90 mm HE, M71 Projectile, Lot WC-91: | | Glass Cones Steel Cones | | |
| Cringte Wi, 10 21107 Interstein Total Ne. of Fregments: 703 For TNT 703 For Subject HE 703 Jineb HE, M42A1 Projectile, Lee KC-5: Demsity, gm/cc Demsity, gm/cc 1.60 Charge Wt, 1b 0.848 Total Ne. of Fregments: For Subject HE For TNT 514 For Subject HE 514 Fregment Velocity: fr/sec (k) Ar 91 b 2500 Ar 91 b 2500 Mathod of Leading: 1. Cast Fregment Velocity: fr/sec (k) Ar 91 b 2500 Mathod Fregment Velocity: fr/sec (k) Ar 91 b 2500 Mathod Dary Head Ing Density: gm/cc See bulow Fregment Velocity: fr/sec (k) Ari: 2350 Density: gm/cc Leading Density: gm/cc Air: Head Ing Density: gm/cc Head Ing Density: gm/cc Leading Density: gm/cc Air: Head Ing Density: gm/cc Head Ing Density: gm/cc Leading Density: gm/cc Air: Head Ing Density: gm/cc Head Ing Density: gm/cc Leading Density: gm/cc Air: Head Ing Density: gm/cc <th>Density, gm/cc</th> <th>1.60</th> <th>Hole Volume 100 1.00</th> | Density, gm/cc | 1.60 | Hole Volume 100 1.00 | | |
| For TNT 703 For Subject HE 703 3 Inch HE, M42A1 Projectile, Let KC-5: Demain, gm/dc Demain, gm/dc 1.60 Charge Wt, Ib 0.848 Tetal Ne. of Fregments: For Subject HE For Subject HE 514 Fregment Velocity: Hr/sec (k) At 9 /b 2560 At 9 /b 2560 At 9 /b 2560 At 25 /a ft 2560 Density, gm/cc 1.58 Mathod of Loading: 1. Cast Fregment Velocity: H/sec (k) At 9 /b 2560 At 9 /b 2560 At 9 /b 2560 Start Relative to TNT): Hozerd Class (Quontity-Distance) Air: Pressure Incuber 100 Impulse 100 Incert Weter: 100 Incert Weter: 100 Incert Weter: 100 Impulse 100 Inder Yessure 100 Inder W | Charge Wt, Ib | 2.104 | Hole Depth 100 100 | | |
| For TNT703 For Subject HE703Jinck HE, M42A1 Projectile, Let KC-5: Density, gn/cc1.60Density, gn/cc1.60Charge Wt, ib0.888Total No. of Fregments: For Subject HE514For Subject HE514For Subject HE514For Subject HE2600At 21 tr2500Steringe Wt, ib1.58Mathed of Loading:1. Cast 2. PressoidFregment Velecity: Marked et TNT2600At 21 tr2500Steringe:1.58MethodBrayVisc Kressure100Impulse100Incrv Velecity: trouble100Marked et StationIone at 65°CIncrv Velecity: trouble100Air: Deck Pressure100Under Weter: trouble100Impulse100Loeding Density: for provise100Undersynamic trouble100Undersynamic trouble100Undersynamic trouble100Undersynamic trouble100Undersynamic trouble100Undersynamic trouble100Undersynamic trouble100Undersynamic trouble100Energy100Undersynamic trouble100Energy100Undersynamic trouble100Energy100Undersynamic trouble100Energy trouble100Energy trouble100 <td>Total No. of Fragments:</td> <td></td> <td>Calar Light vellow</td> | Total No. of Fragments: | | Calar Light vellow | | |
| 3 inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc 1.60 Charge Wr, Ib 0.848 Total No. of Fregments: For TNT For Subject HE 514 Fregment Velocity: fr/sec (k) Ar 2 ir 2500 Density, gm/cc 1.58 Method Dary Head Pressure 100 Impulse 100 Air: Veck Pressure Veck Pressure 100 Impulse 100 Air: Compatibility Group Croup I Veck Pressure 100 Impulse 100 Incertage | For TNT | 703 | | | |
| 3 inch HE, M42A1 Projectile, Lot KC-5: I.60 Densire, gnr/cc 1.60 Charge Wr, Ib 0.848 Total Na. of Fregments: Sl4 For Subject HE 514 Fregment Velocity: fr/sac (k) Al 7 1r 250 Densire, gnr/cc 1.60 Fregment Velocity: fr/sac (k) Al 7 1r 250 Densire, gnr/cc 1.58 Method Dry Hoad Pressure 100 Impulse 100 Frergy 100 Mir, Confined: 100 Inroulde 100 Inroulde 100 Under Weter: 100 Prok Pressure 100 Inroulde 100 Undergreend: 100 | For Subject HE | 703 | Principal Uses: GP bombs, HE projectiles, | | |
| Density, gn/cc 1.60 Charge Wt, lb 0.848 Total Ne. of Fregments: 514 For Subject HE 514 Fregment Velocity: ft/sec (k) Al 2 Ir 2500 Density, gm/cc See bulow Fregment Velocity: ft/sec (k) Al 2 Ir 2500 Density, gm/cc 1.58 Method Dry Hoard Class (Quantity-Distance) Class 9 Ownsity, gm/cc 1.59 Method Dry Hoard Class (Quantity-Distance) Class 9 Compatibility Group Group I Hoard Class (Quantity-Distance) Class 9 Compatibility Group Group I Exudation None at 65°C Impulse 100 Impulse | 3 Inch HE, M42A1 Projectile, Let KC-5: | | demolition charges, depth charges, | | |
| Total No. of Fragments: For TNTFor Subject HE514For Subject HE514Fragment Velocity: fi/sec(k)A1 25.g. if2500Ornsity, gm/cc1.58Blost (Relative to TNT):MathodPack Pressure100Impulse100Freery100Impulse100Incode f Louding:1. 58MathodDrryBlost (Relative to TNT):Hozord Class (Quantity-Distance)Air:Compatibility GroupOroup IPack Pressure100Impulse100Impulse100Incoder100Incoder100Incoder100Incoder100Deference100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100Incoder100 <td>Density, gm/cc</td> <td>1.60</td> <td>6</td> | Density, gm/cc | 1.60 | 6 | | |
| For TNT 514 For Subject HE 514 Fregment Velecity: ft/sec (k) A1 9 (t 2500 A1 9 (t 2350 Onsity, gm/cc 1.58 Biost (Relative to TNT): Hozard Closs (Quantity-Distance) Air: Peak Pressure Peak Pressure 100 Impulse 100 Incurve 1.52 <td>Charge Wt, Ib</td> <td>0.848</td> <td></td> | Charge Wt, Ib | 0.848 | | | |
| For TNT 514 For Subject HE 514 Fregment Velecity: ff/sec (k) A1 9 1r 2500 A1 25 1g th 2350 Density, gm/cc 1.58 Bleat (Relative to TNT): Hozord Closs (Quantity-Distance) Air: Peak Pressure Peak Pressure 100 Impulse 100 Energy 100 Incustor 100 Energy 100 Incustor 100 Energy 100 Underground: 100 Peak Pressure 100 Incustor 100 Energy 100 Underground: 100 Peak Pressure 100 Impulse 100 Energy 100 Underground: 100 Peak Pressure 100 Impulse 100 Energy 100 Underground: 100 Energy 100 Underground: 100 Energy 100 <tr< td=""><td>Total No. of Fragments:</td><td></td><td>Mothed of Londing: 1. Cast</td></tr<> | Total No. of Fragments: | | Mothed of Londing: 1. Cast | | |
| Leeding Density: gm/cc See bulowFragment Velecity: ft/sec(k)Ai 9 th2500SterygeiAl 25 lu ft2350SterygeiConsity, gm/cc1.58MethodIrryBlost (Relative to TNT):Hazard Class (Quantity-Distance)Class 9Air:Pack Pressure100Group IPeak Pressure100ExudationNone at $65^{\circ}C$ Inculva100ExudationNone at $65^{\circ}C$ Inculva100Loading Density: ga/ce1. Cast $1.58-1.59$ Vinder Water:1001.351.40Inculva100Thermel Conductivity: cul/sec/cm/°C3.5Underpresend: Peak Pressure100Thermel Conductivity: cul/sec/cm/°CUnderpresend: Peak Pressure1001.51 gm/cc (g)Underpresend: Peak Pressure1001.67 gm/cc (g)Underpresend: Peak Pressure1001.67 gm/cc (g)Underpresend: Peak Pressure1001.67 gm/cc (g)Underpresend: Peak Pressure1001.67 gm/cc (g)Underpresend: Peak Pressure1001.67 gm/cc (g)Underpresend: Peak Pressure1001.67 gm/cc (g)Underpresend: Peak Pressure100Underpresend: Peak Pressure100Underpresend: Peak Pressure100Underpresend: Peak Pressure100Underpresend: Peak Pressure100Underpresend: Peak Pressure100Underpresend: <b< td=""><td>For TNT</td><td>514</td><td></td></b<> | For TNT | 514 | | | |
| Frequency Velocity: ft/sec(k)A1 2 fr2500A1 2 fr2360Density, gm/cc1.58Blast (Relative to TNT):Hazard Class (Quantity-Distance)Air:Peak PressurePeak Pressure100Impulse100ExudationNone at 65° CIncurve100Mir:Loeding Density; gm/ccIncurve100Mire100Incurve100Mire100Incurve100Mathematic100Incurve100Mire Water:100Peak Pressure100Undergreund:100Preck Pressure100Undergreund:100Preck Pressure100Undergreund:100Preck Pressure100Undergreund:100Preck Pressure100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impulse100Impu | For Subject HE | 514 | | | |
| Ar 9.14 Ar 251.2 ft2600 2360Sterage:Density, gm/cc1.58MethodDryBlast (Relative to TNT):Hozard Class (Quantity-Distance)Class 9Air:Peak Pressure100Group IPeak Pressure100ExudationNone at $65^{\circ}C$ Impulse100Loading Density; gm/ccIncurve100Loading Density; gm/ccAir:100Loading Density; gm/ccIncurve100Loading Density; gm/ccIncurve100IncurveVinder Water:1001.52Peak Pressure1001.53Under Water:1001.635Peak Pressure1001.52Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:100Underground:1.51Underground:1.52Underground:1.00Underground:1.51Underground:1.51Underground:< | · · · · · · · · · · · · · · · · · · · | ().) | Leeding Density: gm/cc Sec Delow | | |
| At $25t_2$ (t 2360 Sterge:Density, gm/cc1.58MethodDryBlost (Relative to TNT):Hozord Closs (Quantity-Distance)Class 9Air:Peak Pressure100Group IPeak Pressure100ExudationHone at 65° CImpulsa100ExudationHone at 65° CIncuste100Loeding Density; gm/ccIncuste100Loeding Density; gm/ccVick Pressure1001. Cast 1.58-1.59Under Weter:1001. Cast 1.58-1.59Under Pressure1001.35Undergreend:100Thermel Conductivity: cul/sec/cm/°CUndergreend:1001.51 gm/cc (g)Peak Pressure1001.54 gm/cc (g)Undergreend:1001.54 gm/cc (g)Peak Pressure100Undergreend:100Pressure100Impulse100Energy100Undergreend:100Pressure100Impulse100Energy100Undergreend:100Impulse100Energy100Uside at Poom Temperature ($25^{\circ} - 30^{\circ}C$): $100^{\circ}C$ Undergreend:100Temp, $85^{\circ}C$ 0.139 $100^{\circ}C$ Undergreend:100Temp ($25^{\circ} - 30^{\circ}C$): $100^{\circ}C$ Undergreend:2.92 | | | | | |
| MathodIrryBlast (Relative to TNT):MathodIrryAir:Peak Pressure100Impulse100ExudationImpulse100ExudationAir, Confined:InrpulseInrpulse100Mider Weter:100Peak Pressure100Inder Weter:100Peak Pressure100Under Weter:100Peak Pressure100Under State100Under State100Under Gender:100Peak Pressure100Underground:100Peak Pressure100Underground:100Impulse100Impulse100Impulse100Impulse100Impulse100 <td< td=""><td></td><td></td><td>Sterige:</td></td<> | | | Sterige: | | |
| Start (Relative to TNT): Hozard Class (Quantity-Distance) Class 9 Air: Peak Pressure 100 Group I Impulse 100 Exudation None at 65° C Incertain Street 100 Exudation None at 65° C Air: Compatibility Group Group I Marce 100 Exudation None at 65° C Air: Compatibility Group Group I Marce 100 Exudation None at 65° C Air: Compatibility Group Group I Marce 100 Exudation None at 65° C Marce 100 Incertain Street Street Marce 100 Incertain Street Street Marce 100 Intermal Conductivity: Culfsec/cm/°C Undergreend: 100 Intermal Conductivity: Street Pressure 100 Intermal Conductivity: Street Impulse 100 Street Street Impulse 100 Street Street Impulse 100 Street Street | Censity, gm/co | 1.58 | | | |
| Air: Peak Pressure100Compatibility GroupGroup IAir: Peak Pressure100ExudationNone at $65^{\circ}C$ Fmerry100ExudationNone at $65^{\circ}C$ Air, Confined: Impulse100ExudationNone at $65^{\circ}C$ Inder Water: Preak Pressure100Loading Density: gu/ccgu/ccUnder Water: Preak Pressure1001.52 1.59 2. Pressed psi x 10 ³ Under Water: Preak Pressure1001.35 1.40 1.45 1.52 1.55 1.59 1.6Underground: Preak Pressure100Thermal Conductivity: culfsec/cm/°CUnderground: Preak Pressure100Thermal Conductivity: culfsec/cm/°CUnderground: Preak Pressure1001.51 gm/cc (g) 5.28 x 10 ⁻¹⁴ 1.51 gm/cc (g) 5.6 x 10 ⁻¹⁴ 1.51 gm/cc (g) 12.21 x 10 ⁻¹⁴ Underground: Preak Pressure1001.67 gm/cc (g) 12.21 x 10 ⁻¹⁴ 1.67 gm/cc (g) 12.21 x 10 ⁻¹⁴ Underground: Preak Pressure1001.67 gm/cc (g) 12.21 x 10 ⁻¹⁴ 1.67 gm/cc (g) 12.21 x 10 ⁻¹⁴ Energy100Viscosity, poises: Temp, 85°C 100°C0.139 2.92 | | | Method Dry | | |
| Weak Pressure 100 Exudation None at $65^{\circ}C$ Impulse 100 Exudation None at $65^{\circ}C$ Air, Confinad: 100 I. Cast 1.58-1.59 Pressed psi x 10^3 Under Water: 100 1. Cast 1.58-1.59 Pressed psi x 10^3 Under Water: 100 3 5 10 15 20 30 50 1.35 1.40 1.45 1.52 1.55 1.59 1.6 Under you'se 100 Thermal Conductivity: cell/sec/cm/°C Underground: 100 Thermal Conductivity: cell/sec/cm/°C Underground: 100 1.51 gm/cc (g) 7.12 x 10^{-14} 1.54 gm/cc (g) 12.21 x 10^{-14} Underground: 100 1.67 gm/cc (g) 12.21 x 10^{-14} 1.67 gm/cc (g) 12.21 x 10^{-14} Impulse 100 1.67 gm/cc (g) 0.139 100°C 0.095 Bulk Modulus et Poom Tempersture ($25^{\circ} - 30^{\circ}C$): (m) Tempersture ($25^{\circ} - 30^{\circ}C$): (m) Underground: 1000 100°C 0.095 2.92 | Stort (Relative to TNT): | | Hazard Class (Quantity-Distance) Class 9 | | |
| Impulse100ExudationNone at $65^{\circ}C$ Impulse100Ione at $65^{\circ}C$ Air, Confined: Impulse100Ione at $1.58 - 1.59$ Under Water: Preak Pressure1001. Cast $1.58 - 1.59$ 2. Pressed psi x 10^3 Under Water: Preak Pressure1003 5 10 15 20 30 50Preak Pressure1001.35 1.40 1.45 1.52 1.55 1.59 1.60Impulse100Thermal Conductivity: cul/sec/cm/°CUnderground: Preak Pressure100Thermal Conductivity: cul/sec/cm/°CUnderground: Preak Pressure1001.51 gm/cc (g) 5.28 x 10^{-4} Underground: Preak Pressure1001.67 gm/cc (g) 12.21 x 10^{-4} Underground: Preak Pressure1001.67 gm/cc (g) 12.21 x 10^{-4} Underground: Preak Pressure1001.67 gm/cc (g) 2.21 x 10^{-4} Impulse1001.67 gm/cc (g) 2.21 x 10^{-4} | Air: | | Compatibility Group Group I | | |
| Impulse Impulse Finergy Io0 Air, Contined: Impulse Io0 Under Water: Io0 Peak Pressure Io0 Impulse Io0 Underground: Io0 Peak Pressure Io0 Impulse Io0 Impulse Io0 Emergy Io0 Beam gy Io0 Viscosity, poises: Temp, 85°C 0.139 Tempr 85°C 0.139 Io0°C 0.095 Bulk Modulus et Poom Temperature (25°-30°C): (m) Dynes/cm ² x, 10 ⁻¹⁰ 2.92 | Peak Pressure | 100 | | | |
| Air, Confined: Impulse Loading Density: gm/cc Impulse 100 Under Water: Prok Pressure 100 100 $3 5 10 15 20 30 50$ 1.35 1.40 1.45 1.52 1.55 1.59 1.6 Impulse 100 Emergy 100 Underground: Prok Pressure 100 Prok Pressure 100 Impulse 100 Impulse 100 Impulse 100 Viscosity 1.19 gm/cc (g) 5.28 x 10 ⁻¹⁴ 1.51 gm/cc (g) 7.12 x 10 ⁻¹⁴ 1.54 gm/cc (g) 5.6 x 10 ⁻¹⁴ Impulse 100 Emergy 100 Viscosity, poises: Temp, 85°C 0.139 100°C Unk Modulus at Poom Temperature (25°-30°C): (m) 2.92 | Impulse | 100 | Exudation None at 55°C | | |
| Inclusion1001. Cast 1.58-1.592. Pressed psi x 10^3 Under Weter:351015203050Peak Piessure1001.351.401.451.521.551.591.6Impulse100Thermal Conductivity: cul/sec/cm/°CCul/sec/cm/°CCul/sec/cm/°CUnderground: Peak Pressure100Thermal Conductivity: cul/sec/cm/°C7.12 x 10^{-14} Underground: Peak Pressure1001.51 gm/ce (g)5.28 x 10^{-14} Impulse1001.67 gm/ce (b)5.6 x 10^{-14} Impulse1001.67 gm/ce (c)12.21 x 10^{-14} Emergy100Viscosity, poises: Temp, 85° C0.139Under server100Use server0.095Bulk Modulus st Poom Temperature ($25^{\circ}-30^{\circ}$ C): Dynes/cm ² x 10^{-10} (m) 2.92 | Fineray | 100 | | | |
| Under Water: 3 5 10 15 20 30 50 Peak Piessure 100 1.35 1.40 1.45 1.52 1.55 1.59 1.6 Impulse 100 Intermal Conductivity: 1.52 1.55 1.59 1.6 Underground: 100 Intermal Conductivity: 1.51 gm/cc (g) 5.28 x 10 ⁻¹⁴ 1.51 gm/cc (g) 5.6 x 10 ⁻¹⁴ 1.51 gm/cc (g) 5.6 x 10 ⁻¹⁴ 1.51 gm/cc (g) 5.6 x 10 ⁻¹⁴ 1.67 gm/cc (g) 5.6 x 10 ⁻¹⁴ 1.67 gm/cc (g) 1.21 x 10 ⁻¹⁴ 1.54 1.52 1.55 1.59 1.6 Underground: 100 1.51 gm/cc (g) 5.28 x 10 ⁻¹⁴ 1.54 1.51 gm/cc (g) 5.6 x 10 ⁻¹⁴ 1.54 1.54 1.54 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 1.55 | Air, Confined: | | Loading Density: gm/cc | | |
| Peak Pressure 100 1.35 1.40 1.45 1.52 1.59 1.6 Impulse 100 Impulse 100 Impulse | Impulse | 100 | 1. Cast 1.58-1.59 2. Pressed pai x 10 ³ | | |
| $\begin{array}{c ccccc} I & I & I & I & I & I & I & I & I & I $ | | | | | |
| Energy 100 Interded Control of Contro | Peak Pressure | | 1.35 1.40 1.45 1.52 1.55 1.59 1.6 | | |
| Underground: 100 Density 1.19 gm/cc (g) 5.28×10^{-14} Peck Pressure 100 1.51 gm/cc (g) 7.12×10^{-14} Impulse 100 1.67 gm/cc (g) 12.21×10^{-14} Emergy 100 Viscosity, poises: Temp, 85°C 0.139 100°C 0.095 Bulk Modulus st Poom Temperature (25°-30°C): Dynes/cm ² x 10 ⁻¹⁰ 2.92 | Impulsu | | Thermal Conductivity: | | |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | Energy | 100 | | | |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | Underground: | | Density 1.19 gm/cc (g) 5.28×10^{-1} | | |
| Impulse 100 1.67 gm/cc (g) 12.21 x 10 ⁻⁴ Energy 100 Viscosity, poises: Temp, 85°C 0.139 100°C 0.095 Bulk Modulus at Poom Temperature (25°-30°C): (m) Dynes/cm ² x 10 ⁻¹⁰ 2.92 0.100 | | 100 | $1.51 \text{ gm/cc} (g) 7.12 \times 10^{-4}$ | | |
| Energy 100 <u>Viscosity, poises:</u> Temp, 85°C 0.139 100°C 0.095 Bulk Modulus at Poom <u>Temperature (25°-30°C):</u> (m) <u>Dynes/cm² x 10⁻¹⁰ 2.92</u> | Impulse | 100 | 1.67 gm/cc (g) 12.21×10^{-4} | | |
| Temp, 85°C 0.139 100°C 0.095 Bulk Modulus at Poom 0.095 Temperature (25°-30°C): (m) Dynes/cm² x 10 ⁻¹⁰ 2.92 | Enwrgy | 100 | | | |
| Bulk Modulus at Poom <u>Temperature (25^o-30^oC):</u> (m) Dynes/cm ² x 10 ⁻¹⁰ 2.92 | | | Temp, 85°C 0.139 | | |
| $\frac{\text{Temperature } (25^{\circ}-30^{\circ}\text{C}):}{\text{Dynes/cm}^2 \times 10^{-10}} \qquad (m)$ | | | | | |
| | | | Temperature $(25^\circ - 30^\circ C)$: (m) | | |
| | | | Dynes/cm ² x 10 ⁻¹⁰ 2,92 Density, gm/cc 1.56 | | |

INT (Trinitrotoluene)

Effect of Temperature on Rate of Detonation: (1) Temperature of Charge, °C -54 21 60 60 16 16 24 Hours at Temperature 72 Density, gm/cc 1.64 1.63 1.62 1.64 6700 6820 6510 Rate, meters/second 6770 Sensitivity to Electrostatic Discharge, Joules; Through 100 Mesh:

Unconfined 0.05 Confined 4.4

Impact Sensitivity versus Temperature:

Picatinny Arsenal Apparatus, 2 kg wt, inches:

| °c | inches |
|---------|-------------------------|
| _40 | 17 |
| Room | 14 |
| 80 | 7 |
| 90 | 3 |
| 105-110 | 2 (5 expl in 20 trials) |

Impact Sensitivity versus Loading Method, Large Impact Apparatus, Inches:

Pressed at 1.60 gm/cc Cast at 1.60 gm/cc

T

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Rifle Bullet Impact Sensitivity versus Temperature, Confinement:

70 26

| Stendard Iron Bomb; | Room Temperature | 105° to 110°C |
|---------------------------------------------------|------------------------|---------------|
| No Air Space Trials Exp. asions | 10 l very low order | 10 7 |
| Air Space Trials Explosions | 10 0 | 10 0 |
| Tin or Cardboard Bombs: | | |
| With or Without Air Space Trials Explosions | 10 0 | 10 0 |

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TNT (Trinitrotoluene)

Explosion Temperature versus 'INT Initial Temperature:

| TNT Temperature, Initial | Explosion Temperature, ^O C | | | | | | |
|-----------------------------------------------------------|---------------------------------------|--|--|--|--|--|--|
| Room | 470 (Decomposes) | | | | | | |
| 105°-100°C | 480 (Decomposes) | | | | | | |
| Explosion Temperature versus Confinement, ^O C: | | | | | | | |
| Unconfined | Decomposes 470 | | | | | | |
| Sealed in glass capillary | Explodes 320-335 | | | | | | |

Viscosity at 80.5°C:

Viscosity, X, cp log X = 0.046 S + 1.25 S = % solid in slurry Farticle size effect, small

Density, gu/ce:

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| °c | State | gm/cc |
|----------|--------|-------|
| 27 to 70 | Flaked | 1.65 |
| 80 | Flaked | 1.64 |
| 82 | Liquid | 1.43 |
| 87 | Liquid | 1.48 |
| 95 | Liquid | 1.47 |

Solubility of TNT, gm/100 gm (\$), in: (f)

| War | Water Acetone | | Benzene | | Toluene | | |
|---------------------|------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------|----------------|----------------------------------|---------------------------|---------------------------------|
| °c | ž | °c | z | <u>°c</u> | ¥ | °C | ž |
| 8580 8580 | 0.0100 0.0130 0.0285 0.0675 | 80 t 80 80 t 80 80 t 80 80 80 80 80 80 80 80 80 80 80 80 80 8 | 57 109 228 600 | 89580 89580 | 13 67 180 478 7 2000 | 89 68 68 68 0 | 28 55 130 367 >1700 |
| | arbon chloride | Et | her | Chlor | oform | | <u>hloro-</u> ylene |
| °c | ž | °c | ž | °c | ž | °c | ž |
| 0 40 60 75 | 0.20 0.65 1.75 6.90 17.34 24.35 | 0 | 1.73 3.29 | 0 20 40 | 6 19 66 302 | 25 55 | 3.5 60 |

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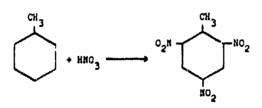
....

| | | | <u></u> | | | | |
|----------------------|---------------------------|------------------------------|--------------------------------|----------------|----------------------|---------------------------------|-----------------------------------|
| Pyrt | ldine | Methyl | acetate | | iloride | ethyl- | hoxy~ acetate |
| <u>°c</u> | ź | °c | ٤ | • <u>c</u> | ź | °c | _2 |
| 20 40 60 70 | 140 250 640 1250 | 20 40 50 | 73 135 280 | 20 40 60 | 34 123 460 | 20 45 50 | 29.5 49 96 |
| | chloro- | An | <u>iline</u> | | propyl cohol | Ethe | nol |
| °c | 2 | °c | ž | °c | ž | °c | . 2 |
| 20 40 50 | 18 50 100 | 10 30 50 70 80 | 6.1 11.5 29 74 130 | 20 50 20 | 0.76 1.96 2.95 | 0 22 20 20 00 70 | 0.62 1.25 2.85 8.4 25 |
| 1:00 | utyl slooh | 0] | <u>c</u> | arbon dist | ulfide | Chlorot | enzene |
| <u>°c</u> | | ź | - | <u>'c</u> | ž | °C | é |
| 0 20 40 50 | | 0.20 0.61 1.41 2.35 | 2 | 0 0 0 | 0.14 0.44 1.4 | 20 30 40 50 | 35 51 79 116 |

TNT (Trinitrotoluene)

Preparation:

(AC 7258, 7259, 7260 - Nitration Kinetics) (<u>Chemistry of Powder and Explosives</u>, Davis)



In older processes trinitrotoluene (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 6d/1b. In England, a two stage continuous process was developed during World War II; in the first counter current strge, toluene was nitrated to the mono stage mononitrotoluene (MNT); in the second stage, also counter current, MNB 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 (HSO_2-) 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 INT from DNT:

 $\frac{d(\mathrm{INT})}{dt} = K(\mathrm{NO}_2^+) [K'(\mathrm{HSO}_4^-) + K''(\mathrm{H}_2\mathrm{SO}_4)] (\mathrm{DNT})$

<u>Three 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° C and a mixture of 54.5 gm mitric 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 continued 2 more hours.

While the dimitration mixture is still at 90° C, 145 gm fuxing sulfuric acid (oleum containing 15% free SO₃) 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 egitation at 100° -115°C over 12-2 hours. The mixture is stirred at 100° -115°C for 2 more hours, cooled, filtered, and the TNT cake broken up and vashed with water. The TNT is washed 3-4 times with hot water (85° - 95° C) with good agitation. The product can be purified either by recrystallization from alcohol or by washing it with 5 times its weight of 5% sodium bisulfite solution at 90° C for 5 hour with vigorous stirring, washing with hot water until the washings are colorless, and cooling slawly with stirring to granulate the product.

Origin:

Why was first prepared in 1863 by Wilbrand (Ann 128, 178), later by Beilstein and Nuhlberg (Bor 3, 202 (1870) and also Tiemann (Ber 3, 217 (1870), each using different methods of starting materials. It was nearly 30 years later when Housermann undertook its manufacture on an industrial scale (Z angev Chem, 16)1, p. (G; J Chem Ind, 1891, p. 1028). After 1901 TNT began to be used extensively as a military explosive and Germany Lacause the first nation to adopt it as a standard shell filler (1902-1904). During World War I all the major powers of the world were using TNT, with the quantity used limited only by the available supply of toluane. Prior to World War II the development of synthetic toluene from petroleum made available in the United States, an almost unlimited supply of this raw material. Because of the general suitability of TNT for melt-loading and it a extensive use in binary and ternary explosive mixtures, TNT is considered the most important military explosive known today.

Destruction by Chemical Decomposition:

THT is decomposed by adding it slowly, while stirring, to 30 times its weight of a solution prepared by dissolving 1 part of modium sulfide $(Na_2S^{-9})!_2O)$ in 6 parts of water.

References:75

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

⁷³See footnote 1, page 10.

TNT (Trinitrotoluene)

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

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

(d) 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.

(e) Report AC-2587.

(f) International Critical Tables and various other sources in the open literature.

(g) E. Hutchinson, The Thermal Sensitiveness of Explosives. The Thermal Conductivity of Explosive Materials, AC-2861, First Report, August 1942.

(h) A. J. B. Robertson, Trans Farad Society, 44, 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, NDRC, <u>Report on HBX and Tritonal</u>, OSRD No. 5406, 31 July 1945.

(k) R. W. Drake, Fragment Velocity and Panel Penetration of Several Explosives in Simuleted Shells, OSRD Report No. 5622, 2 January 1946.

(1) W. F. McCerry and T. W. Stevens, Detonation Rates of the More Important Military Explosives at Several Different Temperatures, PATH No. 2383, November 1950.

(m) W. S. Cramer, Bulk Compressibility Data on Several High Explosives, NAVORD Report No. 4380, 15 September 1956.

(n) Mantrov, Journal of Chemical Industry (Russia) 6, 1929, pp. 1686-1688.

(o) Also see the following Picatinny Arsenel Technical Reports on TNT:

| <u>0</u> | <u>1</u> | 2 | 3 | <u>4</u> | 2 | 6 | I | <u>8</u> | 2 |
|----------|----------|------|------|----------|------|------|------|----------|------|
| 10 | 291 | 132 | 43 | 364 | 65 | 86 | 47 | 118 | 99 |
| 30 | 551 | 582 | 83 | 694 | 195 | 266 | 87 | 288 | 249 |
| 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 | 807 | 1088 | 701 |
| 1120 | 1041 | 1192 | 743 | 1224 | 975 | 1146 | 817 | 1098 | 739 |
| 1140 | 1121 | 1272 | 853 | 1284 | 1145 | 1276 | 83, | 1128 | 779 |
| 1170 | 1311 | 1292 | 863 | 1294 | 1155 | 1376 | 1107 | 1148 | 799 |
| 1260 | 1391 | 1342 | 1063 | 1304 | 1225 | 1446 | 1147 | 1158 | 889 |
| 1270 | 1431 | 1352 | 1123 | 1314 | 1285 | 1466 | 1217 | 1188 | 929 |
| 1360 | 1451 | 1372 | 1133 | 1341 | 1305 | 1476 | 1247 | 27.98 | 939 |
| 1400 | 1491 | 1402 | 1193 | 1411 | 1315 | 1556 | 1307 | 1228 | 1099 |
| 1460 | 1651 | 1452 | 1243 | 1444 | 1395 | 1636 | 1417 | 1238 | 1109 |
| 1500 | 1821 | 1472 | 1323 | 1454 | 1425 | 1756 | 1427 | 1308 | 1129 |

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INT (Irinitrotoluene)

| <u>0</u> | 2 | 3 | <u>4</u> | 2 | 6 | I | <u>8</u> | 2 |
|------------------------------------------------------|--------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|-------------------|---------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1530 1540 1550 1730 2010 2100 2160 | 1492 1562 1582 1712 1862 | 1373 1493 1553 1633 1693 1823 2063 2163 | 1524 1544 1564 1674 1754 1924 2064 2214 | 1435 1445 1515 1535 1535 1635 1635 1635 1865 1865 1715 1885 2125 2175 | 1956 2216 , | 1437 1457 157 1547 1557 1577 1597 1677 1797 1827 1827 1847 2007 2147 2167 | 1318 1338 1388 1418 1428 1578 1618 1628 1828 1828 1838 1838 1838 2008 2138 2168 | 1139 1179 1259 1289 1339 1369 1419 1429 14469 14469 1529 1549 1629 1689 1729 1809 1729 1809 1819 1819 1819 1819 1819 1819 181 |

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| Composition: % | | Molecular Wsight: | 97 |
|---------------------------------------------------------------|---------------------------------------|-------------------------------------|------------|
| RDX | 42 | Oxygen Belance: | |
| | | CO, % | -55 -26 |
| int | 40 | | |
| Aluminum | 18 | Density: gm/cc Cast | 1.76-1.81 |
| | | Matting Point: *C | |
| C/H Ratio | | Freezing Point: *C | |
| impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | 42 | Boiling Point: "C | |
| Sample Wt 20 mg | - | Refrective Index, 11th | |
| Picatinny Arsenal Apparatus, in. | 9 | nů | |
| Sample Wt, mg | 15 | • n <mark>b</mark> | |
| Friction Pondulum Test: | | Vocuum Stability Test: | |
| Steel Shoe | | cc/40 Hrs, at | |
| Fiber Shoe | | 90°C | |
| Rifle Builet Import Test: Trials | | | |
| | | 120°C | 1.0 |
| Explosions 20 | | 135°C | |
| Partials 80 | | 150°C | |
| Burned O | | 200 Gram Jamb Sand Tast: | |
| Unaffected O | | Sand, gm | 59+5 |
| Explasion Temperature: *C | | Semultivity to Initiation: | |
| Seconds, 0.1 (no cop used) | | Minimum Detonating Charge, gm | |
| | | Mercu y Fulminate | 0.18 |
| 5 Decomposes 260 | | Leod Azide | |
| 10 | | Tetryl | |
| 15 | | Ballistic Martur, % TNY: (a) | 138 |
| 20 | | Treval Test, % TNT: (b) | 130 |
| 75°C International Heat Tast: | | Flaty Dant Test: (c) | |
| % Loss in 48 Hrs | | Method | в |
| 100/C Mark Yout | | Condition | Cost |
| 100°C Heat Test: | 0.00 | Confined | No |
| % Loss, 1st 48 Hrs | | Density, gm/cc | 1.83 |
| % Loss, 2nd 48 Hrs | 0.10 | Brisonce, 96 TNT | 120 |
| Explosion in 100 Hrs | None | | |
| Flammability Indux: | 196 | - Decembra River (d) Confinement | Mone |
| | · · · · · · · · · · · · · · · · · · · | Condition | Cast |
| Hygroscapicky: % 30°C, 90% RH | 0.00 | Charge Diameter, in. | 1.0 |
| | ······ | Density, gm/cc | 1.81 |
| Veletility: | | Rate, meters/second | 7495 |

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|----------------------------------------|------------------|------------------------|-------------------------------------------------------------------------------------------------------------|
| Beaster Sensitivity Test: Condition | (c) Pressed | Cast | Decomposition Equation: Oxygen, atoms/sec |
| Tetryl, gm | 10 | 5 | (Z/sec) |
| Wax, in. for 50% Detona | tion | | Heat, kilocalorie/mole (AH, kcal/mol) |
| Wax, ym | 2 | 0 | Temperature Range, *C |
| Density, gm/cc | 1.64 | 1.81 | Phase |
| Densky, gm/cc | 1.0 4 | 1.01 | Filiase |
| Heat of: | (a) | | Armer Piate Impect Test: |
| Combustion, cal/gm | | 3740 | |
| Explosion, cal/gm | | 1800 | 60 mm Mortar Projectile: (a) |
| Gas Valume, cc/gm | | | 50% Inert, Velocity, ft/sec 185 |
| Formation, cal/gm | | | Aluminum Fineness |
| Fusion, cal/gm | | | |
| | | | 500-lb General Purpose Bembs: |
| Specific Heet: cal/gm/*C | (b) | | |
| At -5°C | | 0.22 | Plate Thickness, Inches |
| Density, gm/cc | | 1.82 | 1 |
| At 15 ⁰ C | | 0.24 | 114 |
| At 15-C | | 0.24 | 14 |
| | | | 144 |
| Burning Rate: | | | |
| cm/sec | | | |
| | (1) | | Bomb Drop Test: |
| Thermel Conductivity: cal/swc/cm/*C | (७) | 9.7 x 10 ⁻⁴ | T7, 2000-16 Semi-Armer-Piercing Bernb vs Concrete: |
| Density, gm/cc | | 1.82 | |
| | ····· | | Max Safe Drop, ft |
| Linear, %/*C =73 to | 75°C 4.7 x | 10 ⁻⁵ (d) | 560-16 General Purpose Bomb ve Concrete: |
| | | | |
| Volume, %/*C | | | Height, ft |
| fierdness, Mohe' Scale: | | | Triola |
| | | | Unoffected |
| Young's Modulus: | (b) | | Low Order |
| - | (0) | $3 \times 10^{10}_{6}$ | High Order |
| E', dynes/cm² | 9.9 | 8 x 10 ⁶ | |
| E, Ib/inch ^a | 202 | | 1000-16 General Purpose Bomb vs Concrete: |
| Density, gm/cc | | 1.77 | |
| ······································ | | | Height, ft |
| Compressive Strength: Ib/Inc | ch' (6) 21 | 00-2300 | Triols |
| Density, gm/cc | | 1.77 | Unoffected |
| Vapar Pressure: | | | Low Order |
| | Aercury | | High Order |
| | | | |
| | | | |
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| Fragmentation Test: | , | Shaped Charge Effectiveness, TNT = 100: 50/36.5/13.5 | | | |
|-------------------------------------|--------------|---------------------------------------------------------|-----------|--|--|
| 90 mm HE, M71 Projectile, Let WC- | 91: | Glass Cones Ste | el Cones | | |
| Density, gm/cc | 1.75 | Hole Volume 150 | 145 ` | | |
| Charge Wt, Ib | 2.316 | Hole Depth 127 | 131 | | |
| Total No. of Fregments: | Sec. | | | | |
| For TNT | 703 | Color: | Gray | | |
| For Subject HE | 891 | | | | |
| 3 inch HE, M42A1 Projectile, Let KC | -5: | Principel Usos: Depth charges, | UOMDS | | |
| Dunsity, gm/cc | 1,79 | | | | |
| Charge Wt, Ib | 0.940 | | | | |
| Total No. of Fragments: | | | | | |
| For TNT | 514 | Mothed of Loading: | Cast | | |
| For Subject HE | 647 | 1 | | | |
| · · | | Loading Density: gm/cc | 1.76-1.81 | | |
| Fregment Velocity: ft/sec | | | | | |
| At 9 ft At 251/2 ft | 2960 2800 | Storage: | <u></u> | | |
| Density gm/cc | | | • | | |
| | | Method | Dry | | |
| Blast (Rela +re to TNT): | (e) | Hazard Class (Quantity-Distance) | Class 9 | | |
| Air: | | Compatibility Group | Group I | | |
| Peak Pre-sure | 122 | | | | |
| Impulse | 125 | Exudation | | | |
| Energy | 146 | · | | | |
| Air, Confined: | | Effect of ! superature on Impact Sensitivity. | | | |
| Impulse | 116 | | | | |
| Under Water: | | Temp. PA Impect Test | | | |
| Peak Pressure | 116 | <u> </u> | <u>z</u> | | |
| Impulse | 127 | 25 15 | | | |
| Energy | 153 | 32 7 104 8 | | | |
| Underground: Peak Pressure | | Viscosity, poises: | | | |
| Impulse | | Temp, 83°C | 4.5 | | |
| Energy | | 95°C | 2.3 | | |
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Preparation:

Torpex is manufactured by heating TNT to approximately $100^{\circ}C$ in a steam-jacketed kettle equipped with a stirrer. Water vet 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.

Toppex, a castable high explosive, was developed in England during World War II for use as a filler in warherds, mines and depth bombs. Several variations in the composition of toppex have been evaluated but the following are those used in service munitions:

| | Torpex 2 unwaxed | Torpex 2 waxed | Torpex 3 |
|-------------------------------------------|---------------------|-----------------------------|-----------------------------|
| | (a) | (b) | (c) |
| RDX, % INT, % Aluminum, % Wax, % | 42 40 18 | 41.6 39.7 18.0 0.7 | 41.4 39.5 17.9 0.7 |
| Calcium chloride, 3 | | | 0.5 |

(a) Made from Composition B-2 or 60/40 Cyclotol.

(b) Made by the addition of aluminum to Composition B.

(c) Made by the addition of calcium chloride to Torpex 2.

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Wax has the undesirable effect of (1) tending to compute 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 1.66-1.70 for waxed torpex, and (3) lowering the compressive strength from 3700 psi to 1970 psi for waxed torpex. 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>, OSRD No. 5406, 31 July 1945.

(b) Philip C. Keenan and Dorothy C. 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.

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

⁷⁶See foctnote 1, page 10.

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

Torpex

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

(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 Cavity Effect with Explosive Composition, NDRC Contract W672-OPD-5723.

(g) Also see the following Picstinny Arsenal Technical Reports on Torpex:

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| <u>o</u> | 1 | 2 | 3 | 2 | <u>6</u> | <u>7</u> | <u>8</u> |
|----------|------|------|------|------------------------------|----------|----------|----------|
| 1530 | 1651 | 1292 | 2353 | 1585 1635 1885 2355 | 1796 | 1797 | 1838 |

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1,3,5-Triamino_2,4,6-Trinitrobenzene (TATNB)

| Composition: % | | Molecular Weight: (C6H6N606) | 258 |
|------------------------------------------------------------------------------------------------------------|------------|----------------------------------------------------------------------------------------------------------|----------------|
| с 27.9 н 2.3 о ₂ ^{N-} | NH2 NO2 | Oxygen Belence: CO3 % CO % | -56 -19 |
| N 32.6 H ₂ N- | NII2 | Density: gm/cc Crystal | 1.93 |
| 0 37.2 | NO2 | Molting Point: °C 330 (b, r) | 360 (=) |
| C/H Rotio 0.302 | | Freezing Point: *C | |
| Impact Sansitivity, 2 Kg Wt: | | Boiling Point: 'C | |
| Bureau of Mines Apparatus, cm Sample Wt 20 mg Picatinny Arsenal Apparatus, in. 11 Sample Wt, mg 7 | | Refrective Index, ng ng ng | |
| Friction Pendulum Test: Steel Shoe Fiber Shoe | | Vacuum Stubility Test: cc/40 Hrs, ut 90°C | |
| Rifle Buile: Impact Test: Tri | als | 100°C (a, b) | 0.36 |
| | % | 135°C | |
| Explosions Partials | | 150°C | |
| Burned Unaffected | | 200 Gram Bomb Sand Tast: Sand, gm | 42.9 |
| Explosion Temperature: Seconds, 0.1 (no cap used) 1 5 10 | ۰c | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryi | 0.30 |
| 15 | | Sellistic Martur, % TNY: | |
| 20 | | Treuzi Test, % TNT: | |
| 75°C Internutional Heat Tout: % Loss in 48 Hrs | | Plete Dent Yest: Method | |
| 100°C Hest Test: | | Condition | |
| % Loss, 1st 48 Hrs | 0.00 | Confined Development | |
| % Loss, 2nd 48 Hrs | 0.00 | Density, gm/cc Brisance, % TNT | |
| Explosion in 100 Hrs | None | | |
| Flommability Index: | | Confinement | None |
| Hygroscopicity: % | | Condition Charge Diameter, in. | Pressed 0.5 |
| Veletility: | ···· | Density, gm/cc | 1.80 |
| • | | Rate, meters/second | 7500 |

1,3,5-Triamino-2,4,6-Trinitrobenzene (TATNB)

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| Fragmantation Test: | jhaped Charge Effectiveness, $TNT = 1$ | 100: | |
|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------|--|
| 90 mm HE, M71 Projectile, Lot WC-91; Density, gm/cc Charge Wt, Ib | Gloss Cones Steel Cones Hole Volume Hole Depth | | |
| Total No. of Fragments: For TNT For Subject h ^{. v.} | Color: | Yellow | |
| 3 inch HE, M42A1 Projectile, Lot XC-5: Density, gm/cc Charge Wt, Ib | Principal Uses: | | |
| Total No. of Fragments: For TNT For Subject HE | Marhod of Lasding: | Pressed | |
| Fregment Veloc'ry: ft/sec At 9 ft | Leading Density: gm/cc At 50,000 psi | 1.80 | |
| At 25½ ft Density, gm/cc | Sterege: Method | Dry | |
| Blast (Relative to TNT): | Hazard Class (Quantity-Distance) | | |
| Air: Peak Pressure Impulse Energy | Hole Volume Hole Depth Color: Yellow Principal Uses: Marked of Leading: Pressed Leading Density: gm/cc At 50,000 psi 1.80 Storage: Method Method Dry | | |
| Air, Confined: Impulse | | | |
| Under Water: Peuk Pressure Impulse Energy * | 1,345 1,675 1,675 1,882 | 5628 6550 6575 7035 | |
| Undergraund: Peak Pressure Impulse Energy | | 2831 | |
| | | | |

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1,3,5-Triamino-2,4,6-Trinitrobenzene (TAINB)

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Preparation:

(a)

Absolute alcohol (200 milliliters) was saturated with ammonia and then 12.5 gm (0.028 mol) or 1, 3, 5-tribromo-2, 4, 6-trinitr benzene, prepared according to Hill (NAVORD Report No. 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 under reflux for thirty minutes. filtered hot, and the insoluble product collected on a Buchner funnel. The product was washed with water, alcohol, and dried. The 4.7 gm of material recovered was recrystallized from nitrobenzene.

A disadvantage of the above method was that it could not be used for the preparation of large quantities of TATNB. Since it did not seem feasible to develop a new method of preparation, an investigation was made of the reported amination reactions (see Origin below). An attempt 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 f): 1,3,5-trichlorobenzene was nitrated "in one step" to 1,3,5-trichloro-2,4,6-trinitrobenzene in 55% yield. The crude nitration product was aminated in benzene with ammonia gas to TAINB, in

Origin:

TAINE was prepared for the first time in 1882 by C. L. Jackson and J. F. Wing, who found the compound insoluble in alcohol, ether, chlorod'orm, benzene, and glacial acetic acid; and soluble in nitrobenzene and aniline (Amer Chem Journal 10, 282 (1888)). B. Flurscheim and E. L. Holmes prepared 'M'INB from benzene free pentanitroaniline by gradually adding it to 10% aqueous ammonia (J Chem Sou, Pt 2,3045 (1928)). After boiling, an orange-yellow powder melting above 300°C was obtained. This product corresponded to that described by Jackson and Wing. These authors, as well as ralmer (Amer Chem Journal 14, 378 (1892)), attempted to reduce TATNB to hexa-aminobenzene. Either decomposition occurred or a hydrochloride of penta-aminotenzene was formed. Flurscheim and Holmes succeeded in reducing TATNB with phenylhydrazine by heating them together up to 200°C (J Chem Soc, Pt 1,334 (1929)) (Beil <u>13</u>, 301 and EII, 147).

References:77

(a) F. Taylor, Jr., Synthesis of New High Explosives II, Derivatives of 1,3,5-Tribromo-2,4,6-Trinitrobenzene, NAVORD Report No. 4405, 1 November 1956.

(b) L. D. Hampton, <u>Small Scale Detonation Velocity Measurements from May 1951 to May 1954</u>, NAVORD Report No. 3731, June 1954.

(c) E. M. Fisher and E. A. Christian, Explosion Effects Data Sheets, NAVORD Report No. 2986, 14 June 1955.

⁷⁷See footnote 1, page 10.

Tristhylene Glycol Dinitrate (TEGN) Liquid

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| Composition: %CH_2ONO2 | Melecular Weight: (C6H12N208) | 240 | |
|-------------------------------------------------------|-------------------------------|----------------------------------------|--|
| с 29.9 н ₂ с | Oxygen Belance: | Ŷo | |
| | CO2 % CO % | -89 -27 | |
| н 5.4 _{Н2} с ⁻ N 11.7 | Density: gm/cc 20°C 25°C | 1,33 | |
| 0 53.0 H ₂ C 0 | Melting Paint: *C | 1,32 | |
| C/H Rotio 0.177 H2C CH20NO2 | Freezing Point: *C | | |
| Impact Sensitivity, 2 Kg Wt: | Builing Paint: *C | | |
| Bureau of Mines Apparatus, cm 100+ Sample Wt 20 mg | Refrective Index, nº | 1.4540 | |
| Picatinny Arsenal Apparatus, in. 43 | ne | | |
| Sample Wt, mg | ns | | |
| Friction Pendulum Test: | Vacuum Stability Test: | <u></u> | |
| Steel Shoe Unaffected | cc/40 Hrs, at | | |
| Fiber Shoe Unaffected | 90°C | 0 h = | |
| Rifle Builet Impact Test: Trials | 100°C | 0.45 | |
| 96 | 120°C 8 hours | 0.8 | |
| Explosions | 135°C | | |
| Partials | 150°C | | |
| Burned | 200 Gram Bomb Sand Test: | | |
| Unoffected | Sand, gm | 14.7 | |
| Explosion Temperature: *C | Sensitivity to Initiation: | | |
| Seconds, O.I. (no cop used) | Minimum Detonating Charge, gm | | |
|) 5 223 | Mercury Fulminate | | |
| 5 223 10 | Leod Azide | | |
|)5 | Tatryi | | |
| 20 | Ballistic Moster, % 'INT: | ************************************** | |
| AV | Trausi Test, % YNT: | | |
| 75' C International Host Test: % Loss in 48 Hrs | Piete Dent Test: | | |
| /g 6438 IFI 40 FIF3 | Method | | |
| 100°C Hest Test: | Condition | | |
| % Loss, 1st 48 Hrs 1.8 | Confined | | |
| % Loss, 2nd 48 Hrs 1.6 | Density, gm/cc | | |
| Explosion in 100 Hrs None | Brisance, % TNT | | |
| Flammability Index: | Opt-ration Rate: | | |
| | Confinement | S'riby steel | |
| Hygr.stopicity: % | Condition | Liquid | |
| | Charge Diameter, in. | 1.25 | |
| Veletility: 60°C, mg/cm ² /hr 40 | Density, gm/cc | 1.33 | |
| | Rote, meters/second | Fails | |

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Triethylene Glycol Dinitrate (TEGN) Liquid

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| Fragmontation Test: | Shaped Charge Effectiveness, TNT == 100: | | |
|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
| 90 mm HE, M71 Projectile, Lut WC-91: Density, gm/cc Charge Wt, ib | Gloss Cones Steel Cones Hole Volume Hole Depth | | |
| Total No. of Fragments: For TNT | Color: | | |
| For Subject HE | Principel Uses: Ingredient of rocket and double base propellants Method of Loading: | | |
| 3 Inch HE, M42A1 Projectile, Let KC-5: Density, gm/cc Charge Wt, ib | | | |
| Total No. of Fragments: For TNT For Subject HE | | | |
| | Loading Denuity: gm/cc | | |
| Fregment Velocity: ft/sec At 9 ft At 251/2 ft | Storages | | |
| Density, gr./cc | Method 7,1 guið | | |
| Blast (Relative to TNT): | Hoxard Class (Quantily-Distance) | | |
| Air: Peok Pressure | Compatibility Group | | |
| Impulse | Exudation | | |
| Energy Air, Confined: Impulse | Solubility in Water, gm/100 gm, at: 25°C 0.55 60°C 0.68 | | |
| Under Water: Peak Pressure | Solubility, gm/100 gm, t 25°C, in: | | |
| impulse Energy | Ether * Alcohol * 2:1 Ether:Alcohol * | | |
| Underground: Peak Pressure | Acetone - Viscosity, centipoises: | | |
| Impulse | Temp, 20 ⁰ C .13.2 | | |
| Energy Heat of: | Hydrolysis, β Acid: 10 days at 22 ⁰ C 0.032 5 days at 60 ⁰ C 0.029 | | |
| Combustion, cal/gm 3428 Explosion, cal/gm 357 Gas Volume, cc/gm 851 | Vapor Pressure: <u>OC</u> 25 NEA Mercury C C C C C C C C | | |

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Triethylene Glycol Dinitrate (TEGN) Liquid

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Origin:

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Lourence prepared triethylene glycol in 1863 by heating glycol with ethylene bromide in a scaled, tube at $115^{\circ}-120^{\circ}C$ (Ann (3) <u>67</u>, 275). Later in the same year Wurtz prepared triethylene glycol by heating ethylene oxide with glycol at $100^{\circ}C$. By action of nitric acid triethylene glycol was oxidized to $(H_{2}00C \ CH_{2} \cdot 0 - CH_{2})_{2}$ (Ann (3) <u>69</u>, 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 a plasticizer for nitrocellulose is being replaced by other liquid nitrates.

Preparation:

Triethylene 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 triethylene 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 TEG 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 ice and extracted three times with ether. The combined extract is water-washed to a pH of about 4, shaken with an excess of acditue bicarbonate solution, and further washed with 1% sodium bicarbonate solution until the washings are colorless. The ethereal solution is water-washed until it has the same pH value as distilled water. It is carefully 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 minimal rate of loss in weight is attained. The yield is 1.3^4 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

(a) See the following Picatinny Arsenal Technical Reports on TEGN:

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| <u>3</u> | 2 | 6 | <u>7</u> | <u>8</u> |
|--------------|------|--------------|--------------|----------|
| 1953 2193 | 1745 | 1786 2056 | 1767 1817 | 1638 |

78See footnote 1, page 10.

Trimonite

| Composition: % | Malacular Weight: | 217 |
|----------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|------------------------------------------------|
| Picric Acid 88 - C | Oxygen Balance: CO ₂ % CO % | -62 -14 |
| Mononitronsphthalene 12 10 | Density: gm/cc Cast | 1.60 |
| | Making Point: "C | 90 |
| C/H Ratio | Freezing Paint: *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 60 Sample Wt 20 mg Picationy Ansenal Apparatus, in. 10 | Boiling Point: *C Explodes Refrective Index, no | 300 |
| Picatinny Arsenal Apparatus, in. 10 Sample Wt, mg | nដ កដ្ឋ | |
| Friction Pondulum Test: Steel Shoo Fiber Shoe | Vecuum Stebillity Test: cc/40 Hrs, at 90°C 100°C | |
| Bilie Bullet Impact Test: Trials % Explosions 0 Partials 0 | 120°C 135°C 150°C | 0.9 |
| Sumed 0 Bunaffected 100 | 200 Grem Bomb Sand Test: Sond, gm | 44.2 |
| Explosion Tempereture: *C Seconds, 0.1 (no cap used) 1 | Sensitivity to Initiation: Minimum Detonating Charge, gm Mercury Fuiminate | · <u>······························</u> |
| 5 Decomposes 315 10 | Leod Azide | 0.20 |
| 15 | Tetryi | 0.04 |
| 20 | Ballistic Morrar, % TNT: | |
| 75°C International Heat Test: | Treuzi Test, % TNT: | |
| % Loss in 48 Hrs | Plate Dent Test: Method | |
| 100°C Heet Test: | Condition | |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd 48 Hrs | Density, gm/cc Brisance, % TNT | |
| Explosion in 100 Hrs | | , 19 19 - 19 19 19 19 19 19 - 19 19 |
| Flammability Index: | Confinement | None |
| Hygroscopicity: % | Condition Charge Diameter, In. | Cast 1.0 |
| Veletility: | Density, gm/cc Rate, meters/second | 1.60 7020 |

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| Fregmentation Test: | Sheped Charge Effectiveness, TMT = | ≖ 100: |
|----------------------------------------|----------------------------------------------------------------|----------------------------------|
| 90 mm HE, M71 Projectile, Let WC-91: | Gloss Cones Ste | el Cones |
| Density, gm/cc | Hole Volume | |
| Charge Wt, Ib | Hole Depth | |
| Total No. of Fragments: | Caleri | |
| For TNT | | |
| For Subject HE | Principal Uces: TNT substitute | in projectiles |
| 3 inch HE, MAZAT Projectile, Let KC-5: | and bombs | |
| Density, gm/cc | | |
| Charge Wt, Ib | | |
| Total No. of Fregments: | Method of Looding: | Cast |
| For TNT | | |
| For Subject HE | Looding Densitys gm/cc | 1.60 |
| Fregment Velocity: ft/sec | | |
| At 9 ft At 251 <u>4</u> ft | Sternge: | |
| Density, gm/cc | | |
| | Method | Dry |
| Blast (Relative to TNT): | Hazard Class (Quontity-Distance) | Class 9 |
| Air: | Compatibility Group | Group I |
| Peak Pressure | | - |
| Impulte | Exudation | Doudes at 50°C |
| Energy | | |
| Air, Cunfined: | Preparations | |
| impulse | I We much and all the men | |
| | Picric acid and alpha-mono are melted together in an alu | |
| Under Weter: Peak Pressure | Jacketed melt kettle equipped | With a stirrer. |
| Impulse | Although picric acid alone ro persture for its melt loading | Quires a nigh te (120°C), the |
| Energy | mixture forms a sutestic melt | ing at 49° C. C |
| •• | gerous metallic picrates. The | |
| Underground: | interest as an emergency subs | |
| Peak Pressure | | |
| Impulse | | |
| Energy | | |
| | | |

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Trimonite

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Origin:

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 objectionable 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-mononitronaphthalene mixture ($49^{\circ}C$), Tridite exudes when stored at elevated temperatures. It does not possess the disalvantages of picric acid (corrosive action on metals, ease of decomposition, etc.) and is a comparatively inexpensive substitute for TNT.

References: 79

(a) See the following Picatinny Arsenal Technical Reports on Trimonite:

| 2 | 5 | <u>6</u> | <u>8</u> |
|------|------|----------|----------|
| 1352 | 1325 | 926 | 1098 |
| 1372 | | 976 | 1838 |

⁷⁹See footnote 1, page 10.

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2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrate (TNETB)

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| Composition: | Molecular Weight: (C ₆ H ₅ N ₅ 0 ₁₄) | 3 86 |
|---------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------|
| ъ с 18.6 | Oxygen Belance: | |
| н 1.6 | CC ₂ % CO % | -4.2 20.8 |
| O-CH_C(NO_) | Density: gra/cc Form I | 1.78 |
| N 21.8 C = 0 | | |
| 0 '58.0 C/H Patin 0 202 CH2CH2C(NO2) 3 | Melting Point: *C | 93 |
| C/H Ratio 0.202 | Freezing Point: "C | |
| Empect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Boiling Point: "C | |
| Somple Wt 20 mg | Refrective Index, no Form I (e |) |
| Picatinny Arsenal Apparatus, in. Sample Wt, mg | Crystel Axis a | 1.518 |
| 50% point, cm (a) 20 | β Τ | 1.527 1.546 |
| Friction Pondulum Test: | Vocuum Stability Test: | |
| Steel Shoe | cc/40 Hrs, at | |
| Fiber Shoe | 90°C | |
| Rifle Buildt Impoct Test: Trials | 100°C 48 hrs | 0.60 |
| % | 120°C | |
| Explosions | 135°C | |
| Partials | 150°C | • |
| Burned | 200 Gram Bomb Sand Toot: | |
| Unaffected | Sand, gm | |
| Explosion Temperature: °C | Sonsitivity to Initiation: | |
| Seconds, 0.1 (no cop used) | Minimum Detonating Charge, gm | |
|] 7 500 materia (43 hash ham) (a) | Mercury Fulminate | |
| 5 50% point (Alhot bar) (a) 225 | Lead Azide | |
| 10 15 | Tetryi | |
| 20 | Ballistic Mortar, % TNT: (b) | 1.36 |
| | Tieuzi Tent, % TNT: | |
| 75°C International Heat Tout: | Piete Dent Test: | |
| % Loss in 48 Hrs | Method | |
| 100°C Heat Test: | Condition | |
| % Loss, 1st 48 Hrs | Confined | |
| % Loss, 2nd +1 Hrs | Density, gm/cc | |
| Explosion in 100 lrs | Brisance, % TNT | |
| | - Detenation Rate: | |
| Flommability Index: | Confinement | |
| Hygrescepicity: % 30°C, 90% RH 0.00 | Condition | |
| 75°C, 5 months Ni1 (a) | Charge Diameter, in. | |
| Valetility: | Density, gm/cc 1.60 | 1.76 |
| · | Rate, meters/second 7760 | 829) |

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2,2,2-Trinitroethy1-4,4,4-Trinitrobutyrate (TNETB)

| Booster Sensitivity Test: | | Decomposition Equation: | 4.4 x 10 ²¹ |
|------------------------------------------------------|------|-----------------------------------------|------------------------|
| Condition | | Öxygen, atoms/sec (Z/sec) | 4.4×10^{-1} |
| Tetryl, gm Wax, in. for 50% Detonation | | Heat, kilocatorie/mole | 43.4 |
| Wax, am | | (AH, kcal/mol) Temperature Range, °C | |
| vvax, gm Density, gm/cc | | Phase | Liquid |
| | | Fliuse | maara |
| Hees of: Combustion, cal/gm | 1685 | Armar Plate Impact Test: | |
| Explosion, cal/gm | | 60 mm Mortar Projectile: | |
| Gas Volume, cc/gm | | 50% Inert, Velocity, it/sec | |
| Formation, cal/gm | 307 | Aluminum Fineness | |
| Fusion, cal/gm Sublimation, cal/gm (est) | 864 | 500-ib General Purpose Bombs: | |
| Specific Heat: cal/gm/*C | | | |
| | | Plate Thickness, inches | |
| | | 1 | |
| | | 104 | |
| | | 11/2 | |
| | | 134 | |
| Burning Rate: | | | |
| cm/sec | | Somb Drop Test: | |
| Thermei Conductivity: cai/sec/cm/*C | | T7, 2000-16 Semi-Armor-Piercin | g Bomb vs Concrete: |
| | | Max Safe Drop, ft | |
| Coefficient of Expension: | | | |
| Linear, %/*C | | 300-lb General Purpose Bomb v | s Concrete: |
| Volume, %/*C | | Height, ft | |
| | , · | Trials | |
| Hardness, Mahs' Scale: | | Unoffected | |
| Young's Modulus: | | Low Order | |
| E', dynes/cm² | | High Order | |
| E, lb/inch ² | | 1000-ib General Purpose Bomb | Currentes |
| Density, gm/cc | | 1000-10 General Parpose Semis | |
| | · | | |
| Compressive Strength: Ib/inch ^a | | Trials | |
| | | Unaffected | |
| Vapor Prossure: | (e) | Low Order | |
| •C mm Mercury | | High Order | |
| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | | | |
| 85 4.2 - 10 | | | |
| 100 2.3×10^{-3} | | | |
| 120 1.4×10^{-2} | | } | |

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| ragmantation Test: | Shaped Charge Effectiveness, TNT = 100: | | |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------|--|--|
| 90 mm HE, M71 Projectile, Lot WC-91: | Glass Cones Steel Cones | | |
| Density, gm/cc | Hole Valume | | |
| Charge Wt, Ib | Hole Depth | | |
| For TNT | Colories | | |
| For Subject HE | Principal Uses: | | |
| 3 inch HE, M42A3 Projectile, Lot KC-5: | | | |
| Density, gm/cc | | | |
| Chorge Wt, Ib | | | |
| Totel No. of Fragments: | Method of Loading: | | |
| For TNT | • | | |
| For Subject HE | | | |
| | Leeding Density: gm/cc Form I 1.783 Form II 1.677 | | |
| regment Velocity: ft/sec | Liquid, 99°C, 1.551 | | |
| At 9 ft | Storega: | | |
| Density, gm/cc | Method Wet | | |
| | Metrica He C | | |
| lest (Relative to H-6'1: Sphere Cylinder (h) | Hazard Class (Quantity-Distance) | | |
| Air: 1-1b Charge: EV# EV# EV# Peok Pressure 0.91 0.84 0.81 0.75 | Compatibility Group | | |
| | | | |
| Impulse 0.73 0.67 0.74 0.69 | Exudation | | |
| Energy | | | |
| Air, Contined: | Bruceton Safety Test Pesults: (g) | | |
| Impulse | Mean and standard deviation of lengths of | | |
| | 0.300 diameter cylinder across which initia- | | |
| *Inder Water: Peak Pressure | tion is possible for 50% certainty: | | |
| Impulse | THT 0.391 + 0.040 RDX Comp B 0.391 + 0.042 | | |
| Energy | RDX Com B 0.331 7 0.042 T.ETF 0.920 7 0.059 | | |
| Underground: | Absolute Viscosity, poises: (e) | | |
| Peak Pressure | Temp, 93.9°C 0.173 | | |
| Impulse | 106.5°C 0.138 | | |
| Energy equivalent weight of H-b for a unit weight f test mixture for equal performance At the ame test distance; D', equivalent volume of -/ for a unit volume of test mixture for equal | | | |

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2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrate (TNETB)

| Solubility (Room Temperature): | (*) | |
|----------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|---|
| Solvent | Solubility | |
| Water n-Hexane Carbon tetrachloride Ethanol Chloroform Benzene Nitromethane Glacial acetic acid | Insoluble Insoluble Insoluble 5 gm/100 gm solvent 10 gm/100 gm solvent Vary soluble Very soluble | : |
| Ethyl acetate | Very soluble | |

INETE Forms Entectics With the Following Compounds: (a)

| THT BINES (bis(trinitroethyl) succinate) BINEN (bis(trinitroethyl) nitramine) TNB (trinitrobenzene) | 57 80+ 68.5 65 | : |
|---------------------------------------------------------------------------------------------------------------|-------------------------|---|
| Compound A (ChHoN, O, formed by condensation of 1;1-dinitroethane) Trinitroethyl trinitrobenzoate (27%) | 77 80.5 (1) | ; |

Crystallographic Data:

Three polymorphic crystalline forms have been observed. Low temperature Form I goes through a solid-solid transition at 89° C giving Form II. Form II has a melting point of 92.5° to 93° C. On cooling, Form II does not transform reversibly to Form I when 89° 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 very narrow temperature range on the order of 0.2° to 0.3° C near 92.5 °C.

(ď)

(a)

Preparation:

| (NO2)30CH2CH2COC1 + | (NO2)30 | H2OH | H2SOL | |
|------------------------------------------|----------|---------------|------------------|--|
| trinitrobutyryl chloride | trinitro | ethanol | sulfuric acid | |
| (NO2) 3 CCH2 CH2 COOCIT2 C(NO2) |)3 + | HCI. | { | |
| 2,2,2-trinitroethyl-4,4,4-tu butvrate | rinitro- | hydroc aci | bloric d | |

Isboratory 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_0SO_h , the ester can be prepared in yields of 95% to 98% 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 recrystallization from dilute methanol gives a material melting at 92° to 93°C.

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2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrate (TNETB)

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Origin:

(e)

INSTE belongs to a new class of explosives characterized by trinitromethyl groups, $-C(NO_2)_3$. The chemistry of this class of compounds was studied in Germany by Drs. Schenck and Schimmelschmidt, who discovered in 1942-1943 that trinitromethane or nitroform, $HC(NO_2)_3$, was the source of new explosive derivatives. Dr. Schenck prepared the stable solid alcohol, 2,2,2-trinitroethanol, from nitroform and formaldehyde. Dr. Schimmelschmidt reacted nitroform with unsaturated organic compounds, such as acrylic acid, and predicted in 1943 that the ester of 4,4,4-trinitrobutyric acid with trinitroethanol would be an interesting explosive.

In 1947 the U.S. Navy began a program to explore these compounds. The initial task of investigating the chemistry of trinitroethanol was undertaken by the Hercules Powder Company (Navy Contract NOrd-9925). The U.S. Rubber Company studied the chemistry of nitroform (Navy Contract NOrd-10,129). After preparation of the first laboratory samples of TNETB, considerable interest was aroused. In early 1950 the Naugatuck Chemical Division of U.S. Rubber Company was assigned to prepare 100 pounds of TNETB. The Eureau of Ordnance in July 1953 raised the production to 800 pounds with the assistance of the Hercules Powder Company in augmenting the production at Naugatuck (Navy Contract NOrd-11,280). TNETB is a high oxygen content explosive.

References: 80

(a) J. M. Rosen, <u>Properties of Trinitroethyl Trinitrobutyrute TNETB</u>, NAVORD Report No. 1758, 17 December 1950.

(b) Bureau of Mines Report No. 3107, Part IX, Ballistic Mortar Tests on Trinitroethyl Trinitrobutyrate, 5 April 1950.

(c) L. D. Hampton and G. Svadeba, <u>Evaluation of 2,2,2-Trinitroethyl-4,4,4-Trinitrobutyrate</u> as a Constituent of Castable Explosives, NAVORD Report No. 2614, 30 September 1952.

(d) U.S. Rubber Company Quarterly Progress Report No. 23, <u>Synthesis of New Propellants</u> and <u>Explosives</u>, Navy Contracts Nord-10-129 and -12,663, 19 August 1953.

(e) M. E. Hill, O. H. Johnson, J. M. Rosen, D. V. Sickman and F. Taylor, Jr., <u>Preparation</u> and <u>Properties of INETB, a New Castable High Explosive</u>, NAVORD Report No. 3885, 27 January 1955.

(f) M. E. Hill, Synthesis of New High Explosives, NAVOLU Report No. 2965, 1 April 1953.

(g) Jacob Savitt, <u>A Sensitivity Test for Castable Liquid Explosives</u>, Including Results for Some New Materials, NAVORD Report No. 2997, 22 October 1953.

(h) R. W. Gipson, <u>Sensitivity of Explosives</u>, IX <u>Selected Physico-Chemical Data of Ten</u> <u>Pure High Explosives</u>, NAVORD Report No. 6130, 18 June 1958.

⁸⁰See footnote 1, page 10.

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Trinitro Triazidobenzene

| Composition: % | Molecular Weight: (C ₆ 0 ₆ N ₁₂) | 336 | | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|----------------------------------|--|--|
| C 21.4 N_2 N_2 | Oxygen Belance; CO ₂ % CO % | -29 0.0 | | |
| | Density: gm/cc Crystal | 1.81 | | |
| 0 28.6 ⁰ 2 ^N ^{NO} 2 | Matting Point: "C Decomposes | 131 | | |
| C/H Ratio | Freezing Point: 'C | | | |
| Impact Sensitivity, 2 Kg We: | Boiling Point: *C | استورار البرواني والمرار والمرار | | |
| Bureau of Mines Apparatus, cm (&) \$25 Sample Wt 20 mg Picatinny Arsenal Apparatus, in. Sample Wt, mg | Refrective Index, nº nº nº | | | |
| Friction Pendulum Test: Steel Shoe Fiber Shoe | Vecuum Stubility Test: cc/40 Hrs, at 90°C | | | |
| Rifle Bullet Impact Test: Trials | 160°C | | | |
| Sector Se | 135°C | | | |
| Explosions Partials | 150°C | | | |
| Burned | 200 Grem Bomb Sand Yest: | | | |
| Unaffected | Sand, gm | | | |
| Explosion Temperature: °C (a) Seconds, 0.1 (no cap used) 1 1 5 150 10 | Sensitivity to initiation: Minimum Detonating Charge, gm Mercury Fulminate Lead Azide Tetryi | | | |
| 15 20 | Bellistic Morter, % TNT: | | | |
| | Trauzi Test, % PETN: | 90 | | |
| 75°C International Heat Yest: % Loss in 48 Hrs | Plote Dent Test; Method | | | |
| 100°C Heet Test: | Condition | | | |
| % Loss, 1st 48 Hrs | Confined | | | |
| % Loss, 2nd 48 Hrs | Density, gm/cc Brisance, % TNT | | | |
| Explosion in 100 Hrs | | | | |
| Flemmebility Index: | Detonation Rute: Confinement | | | |
| Hygroscopicity: % 30°C, 90% RH 0.00 | Condition Charge Diameter, in. | | | |
| Veletility: | Density, gm/cc | | | |

| ragmentation Test: | i 1 | Shuped Charge Effectiveness, | TNT = 100: | |
|----------------------------------------|--------|---------------------------------------|-----------------------------------------|--|
| 90 mm HE, M71 Projectile, Lot WC-91: | | Glass Cones | Steel Cones | |
| Density, gm/cc | Ì | Hole Volume | | |
| Charge Wit, 15 | i | Hole Depth | | |
| Total No. of Fragments: | | · · · · · · · · · · · · · · · · · · · | | |
| For TNT | | Color: Oz | eenish-yellow | |
| For Subject HE | i | Principal Uses: (c) Ingre | dient of primer wix | |
| 3 inch HE, M42A1 Projectile, Lot KC-5: | | | didno or primer with | |
| Density, gm/cc | 1 | | | |
| Charge Wt, Ib | | | | |
| Total No. of Fregments: | , | Ad-16-14-18-14-14-14 | | |
| For TNT | | Method of Loading: | Pressed | |
| For Subject HE | | Dead presses at about | . 42,000 psi | |
| | | Loading Density: gm/c > | | |
| rogment Velocity: ft/sec | | / At 42,000 psi | 1.75 | |
| At 9 ft At 25¼ ft | | | | |
| Density, gm/cc | | Sterege: | | |
| Density, gm/cc | : 1 | Method | | |
| lust (Relative to TNT): | | Hazard Class (Quantity-Distance) | | |
| Air: | • | Compatibility Group | | |
| Peak Pressure | i i | | | |
| Impulse | ' | Exudation | None | |
| Energy | | | | |
| | 2 | Quelitative Solubilities | | |
| Air, Confined: linpulse | 1 | at Room Temperature: | • | |
| | • | Solvent | Solubility | |
| Under Water: | | Acetone | Readily soluble | |
| Peak Pressure | | Chloroform Alcohol | Moderately soluble Sparingly soluble | |
| Impulse | | Water | Insoluble | |
| Energy | | Compatibility with Metal | s: | |
| Underground: | i | Wet: Does not attack | | |
| Peak Pressure | | or brass. | and write a set of the set | |
| Impulse | | Heat of: | | |
| Énergy | | Combustion, cal/gm | (a) 2554 | |
| | | Burning Rate: | (b) | |
| | | cm/sec | 0.65 | |

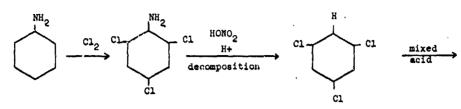
у. У 5

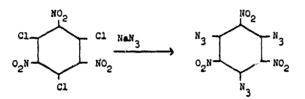
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Trinitro Triszidobenzene

Preparation: (e)





Aniline is chlorinsted to form trichloroaniline. The amino group is eliminated by the diazo reaction. The resulting sym-trichlorobenzene is nitrated. This nitration is carried out by dissolving the material in warm 32% oleum, adding strong nitric acid, and heating to $140^{\circ}-150^{\circ}$ C until no trinitro trichlorobenzene (melting point 187°C) precipitates (Ref f). The chlorine groups are then replaced by azo groups. This is accomplished by adding an acetone solution of the trinitro trichlorobenzene, or better, and powdered substance alone, to an activaly stirred solution of sodium azide in alcohol. The precipitated trinitro triazidobenzene is collected on a filter, washed with alcohol, water and dried. It may be purified by dissolving in chloroform, allowing the solution to cool, and collecting the greepish yellow crystals (melting point 131°C with decomposition).

Origin:

This initiating explosive was first prepared in 1923 by Turek who also perfected its manufacture.

References:81

(a) S. Helf, Tests of Explosive Compounds Submitted by Arthur D. Little, Inc., PATR 1750, 24 October 1949.

(b) A. F. Belyaeva and A. E. Belyaeva CR a.s. USSR <u>52</u>, 503-505 (1946) Chemical Abstracts <u>41</u>, 4310.

A. E. Belyaeva and A. F. Belyaeva, Doklady Akad Nauk. USSR 56, 491-494 (1947).

(c) French Patent 893,941, 14 Normber 1944 (Chemical Abstracts 47, 8374).

(d) A. D. Yoffe, "Thermal Decomposition and Explosion of Azides," Proc. Roy Soc A208, 188-199 (1951).

(e) T. L. Davis, <u>The Chemistry of Powder 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.

⁸¹See footnote 1, page 10.

Tripentaerythritol Octanitrate (TPEON)

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| Composition: | Mrtecular Weight: (C15H24N8O26) | 732 |
|---------------------------------------------------------------|---------------------------------------|---------|
| % С 24.6 Н 3.3 | Oxygen Balance: | |
| N 15.3 | CO2 % | -2.2 |
| 0 56.8 | | |
| CH20N02 CH201 ~2 CH20N02 | Density: gm/cc Crystal | 1.58 |
| 02NOCH2CCH2OCH2CCH2OCH2CCH2ONO2 | Melting Point: *C 82 | to 84 |
| C/H Ratio 0,115 | Freezing Point: *C | |
| Impact Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm | Boiling Point: *C | |
| Sample Wt 20 mg | Refrective Indox, ng | |
| Picatinny Arsenal Apparatus, in. 9 | ng | |
| Sample Wt, mg . 24 | n2 | |
| Friction Pendulum Test: | Vecuum Stebility Test: | ····· |
| Steel Shoe Unaffec | | |
| Fiber Shoe Unaffec | | * |
| | 100°C Pure | 2.45 |
| Rifle Bullet Impact Test: Trials | 120°C Specially purified | 1.94 |
| % Explosions | 135°C | |
| Partials | 150°C | |
| Partials Burned | | |
| ourned Unoffected | 200 Grem Bomb Send Text: Sand, gin | 58.9 |
| | | J0+9 |
| Explasion Temperature: "C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) | Minimum Detonating Charge, gm | |
| 1 5 225 | Mercury Fulminate | |
| 5 22) 10 | Lead Azide | 0.30 |
| • | Tetryi | **== |
| 15 20 | Ballistic Morter, % TNT: | |
| ۷۵ | Trouzi Test, % TNT: | |
| 75°C Internetional Haur Test: % Loss in 48 Hrs | Plate Dem' Test: | |
| 70 LUSS (FI 49 F3F3 | Method | |
| 100°C Heat Test: | Condition | |
| % Loss, 1st 48 Hrs 1.15 | Confined | |
| % Loss, 2nd 48 Hrs 0.75 | Density, gm/cc | |
| Explosion in 100 Hrs None | Brisance, % TNT | |
| | Detenction Rete; | |
| Flammability Index: | Confinement * | None |
| | Condition ' | Pressed |
| Hygroscopicity: % | Charge Diameter, in. | 0.5 |
| N/- 1- altia | Density, gm/cc | 1.56 |
| Velatility: | Rate, meters/second | 7650 |

| AMCP | 706-177 |
|------|---------|
|------|---------|

Tripentaerythritol Octanitrate (TPEON)

| Booster Sonsitivity Text. Condition | | Decomposition Equation: Oxygen, atoms/sec | |
|--------------------------------------------|-------|----------------------------------------------|-------------------|
| Tetryl, gm | | (Z/sec) | |
| Wax, in. for 50% Detonation | | Heat, kilocalorie/mole | 23.1 |
| Wax, gm | | (ΔH, kcal/mol) Temperature Range, °C | 215 to 250 |
| Density, gm/cc | | Phase Phase | Liquid |
| rient of: | | | |
| Combustion, col/gm | 2632 | Armer Plate Impact Test: | |
| Explosion, cal/gm | 1085 | 66 mm Morter Projectilu: | |
| Gas Volume, cc/gm | 762 | 50% Inert, Velocity, ft/sec | |
| Formation, col/gm | | Aluminum Fineness | |
| Susion, cal/grn | | | |
| Specific Neut: cal/gm/*C | | 500-lb General Purpose Bombs: | |
| Specific Impulse: | | Plate Thickness, inches | ĺ |
| lb-sec/lb (cslculated) | 240 | 1 | |
| | | 11/4 | |
| | | 134 | |
| | | 134 | |
| Burning Rute: | | | |
| cm/sec | | Bomb Drop Test: | |
| Thermal Conductivity: cal/sec/cm/*C | | T7, 2000-lb Semi-Armor-Piercing | Bomb vs Concrete: |
| | | | |
| Coefficient of Expansion: | | Max Safe Drop, ft | |
| Linear, %/°C | | 500-15 General Purpose Bomb vs | Concrete: |
| Volume, %/°C | | Height, ft | |
| ······ | | Trials | |
| Hardness, Mohs' Scale: | | Unaffected | |
| Young's Modulus: | ····· | Low Order | |
| E', dynes/cm² | | High Order | |
| E, Ib/inch ² | | | |
| Density, gm/cc | | 1000-ià General Purpose Bomb vi | Generate: |
| | | Height, ft | |
| Compressive Strength: Ib/inch ² | | Trials | { |
| · . | | Unaffected | |
| Yaper Pressure: | | Low Order | 1 |
| *C mm Mercury | | High Order | |
| | | | |
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| | | | |

Tripentaerythritol Octanitrate (TPEON)

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| Fragmentation Test: | Shaped Charge Effect?reness, TNT == 100; |
|---------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| 90 mm HE, M71 Projectile, Lot WC-91: Density, gm/cc Charge Wt, ib | Glass Cones Steel Cones Hole Volums - Hole Depth |
| Total No. of Fragments: For TNT | Color: White |
| For Subject HE 3 inch HE, M42A1 Prejectile, Let KC-3: Density, gm/cc Charge Wt, Ib | Principel Uses: High explosive and as possible plasticizer for nitrocellulose . |
| Total No. of Fragments: For TNT For Subject HS | Method of Leeding: Cast or pressed |
| Fregment Velocity: ft/sac At 9 ft At,25½ ft | Looding Denwity: gm/cc Pressed at 60,000 psi 1.555 Storege: |
| Density, gm/cc | Method Dry |
| Blast (Relative (UTNT): | Hazard Class (Quantity-Distance) |
| Air: Peak Pressure Impulse Energy | Compatibility Group Exudation None |
| Air, Confined: Impulse | <u>Hygroscopicity, Gain or Loss in Wt, %:</u> Tire, Hrs% RH at 30 ⁰ C |
| Under Weter: Peak Pressure | <u>40 70 90</u> |
| ìmpulse Energy | $\begin{array}{cccccccccccccccccccccccccccccccccccc$ |
| Underground: Peak Pressure | 192 -0.04 -0.02 216 -0.004 -0.01 +0.03 |
| Impulse Energy | Solubility: |
| | SolventSolubilityWaterInsolubleAlcoholSolubleChloroformSolubleAcetone, hotVery solubleDenzene, hotVery soluble |

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Tripentaerythritol Octanitrate (TPEON)

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Compatibility With Other High Explosives:

100°C Vacuum Stability Test:

| | NIN | PEIN | RDX | TPEON |
|--------------------------------------------------|------|------|------|-------|
| ml gas/40 hrs, 5 gm sample | 0.11 | 2.15 | 0.39 | 2.45 |
| ml gas/40 hrs, 5 gm sample of 50/50, TPEON/HE | 1.89 | 1.71 | 2.32 | _ |

Dipentaerythritol Hexanitrate (IPEHN)-TPEON Fusions:

| \$ TPEON | % DPEHN | Solidification Time, Days | MP, C |
|----------|---------|---------------------------|---------------|
| 100 | 0 | 1 | 83 |
| 95 | 5 | 3 | 68 |
| 90 | 10 | 3 | 69 |
| 80 | 20 | 5 | 73 |
| 50 | 50 | 30 | 60 (Eutectic) |
| 20 | 80 | 5 | 63 |
| 10 | 90 | 3 | 69 |
| 0 | 100 | _ | 73 |

Preparation:

(a)

Twenty grams (0.054 mol) of nitration grade tripentaerythritol (TPE) (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 TPE used. After addition of the TPE, the reaction mixture was stirred c about one hour at 0° to 5°C and poured into eight times its volume of cracked ice. The

oduct, 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% emmonium carbonate solution, stirred for several hours, filtered and washed with water until the final washings were neutral to litmus. The final product was washed successively with 50 cc each of ethanol and ether. The material drigd in air weighed 37.8 gm or 96% of theory based on TPE. It had a melting range of 71° to 74°C. Crystallization of the crude TPEON from chloro.form was found to be the most suitable method of obtaining pure TPEON.

Origin:

TPEON prepared by the reaction of tripentaerythritol and 99% nitric acid at 0° to 10° C was reported by Wyler in 1945 (J. A. Wyler to Trojan Powder Company: U.S. Patent 2,389, 228, 20 November 1945).

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Tripentaerythritol Octanitrate (TPEON)

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(b) K. Namba, J. Yamashita and S. Tanaka, "Pentaerythritol Tetranitrate," J Ind Explosives Soc (Japan) <u>15</u>, 282-9 (1954); CA <u>49</u>, 11283 (1955).

(c) S. D. Brever and H. Henkin, The Stability of PETN and Pentolite, OSRD Report Mo. 1414.

(d) E. Berlow, R. H. Barth and J. E. Snow, <u>The Pentaerythritols</u>, ACS Monograph No. 126, Reiahold Publishing Corporation, New York, 1958.

82Sae footnote 1, page 10.

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Tritonal, 80/20

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| Composition: % | Molecular Weight: | 81 |
|-----------------------------------------------------------------|-------------------------------|--------------|
| | Oxygon Jalanse: | |
| INT 80 | CO, % | -77 -38 |
| Aluminum 20 | CO % | - 38 |
| | Density: gm/cc Cast | 1.72 |
| | Melting Point: *C | |
| C/H Ratio | Freezing Point: *C | |
| mpect Sensitivity, 2 Kg Wt: Bureau of Mines Apparatus, cm 85 | Boiling Point: *C | |
| Sample Wt 20 mg | Refrective Index, nº | |
| Picatinny Arsenal Apparatus, in. 13 Sample Wt, mg 16 | 0 ⁰ | |
| Sample Wt, mg 16 | n | |
| riction Pendulum Test: | Vecuum Stability Test: | |
| Steel Shoe Unsflected | cc/40 Hrs, at | |
| Fiber Shoe Unaffected | 90°C | |
| Rifig Bullet Impact Test: Tricis | 100°C | 0.1 |
| 96 | 120°C | 0.2 |
| Explosions 60 | 135°C | |
| Partials 0 | 150°C | 0.8 |
| Burned 0 | 200 Gram Bemb Sand Test: | |
| Unaffected 40 | Sand, gm | |
| Explosion Temperature: *C | Sensitivity to Initiation: | |
| Seconds, 0.1 (no cap used) 610 | Minimum Detonating Charge, gm | |
| 1 520 | Mercury Fulminate | |
| 5 Decomposes 470 | Leod Azide | 0.20 |
| 10 465 | Tetryl | 0.10 |
| 15 | Bellistic Moriur, % TNT: ('#) | 124 |
| 20 | | |
| 75°C International Hast Test: | Trues Test, % TNT: (b) | 125 |
| % Loss in 48 Hrs | Plute Dent Test: (c) | _ |
| | Method | B |
| 100°C Heat Test: | Condition | Cast |
| % Loss, 1st 48 Hrs | Confined | No |
| % Loss, 2nd 48 Hrs | Density, gm/cc | 1.75 |
| Explosion in 100 Hrs | Brisance, % TNT | 93 |
| Flammability Index: 100 | Confinement None | None |
| | Continement Note | |
| Hygreecepicity: % 30°C, 90% RH 0.00 | | Pressed |
| | | 1.0 |
| Veletility: | Density, gm/cc 1.71 | 1.72 |
| · | Rate, meters/sacond 6475 | 67 00 |

Tritonal, 80/20

AMCP 706-177

| Beester Sensitivity Test: Condition | (a) | Cast | Decomposition Equation: Oxygen, atoms/sec | | |
|----------------------------------------|----------|-----------------------------|----------------------------------------------|---------------|-------------------------------|
| Tetryl, gm | | 100 | (Z/sec) | | |
| Wax, in. for 50% Deton | ation | 0.58 | Heat, kilocalorie/mole | | |
| Wax, gm | | | (ΔH, kcal/mol) Temperature Range, °C | | - |
| Density, gm/cc | | 1.75 | Phose | | |
| | | | | | |
| Neet of: Combustion, cal/gm | (c) | 4480 | Armer Plate Impact Test: (| e) | |
| Explosion, cal/gm | | 1770 | | | |
| Gas Volunie, cc/gm | | -,,• | 60 mm Morter Projectile: | 509 | >1100 |
| Formation, cal/gm | | | 50% Inert, Velocity, ft/sec | 100 | 12 |
| Fusion, cal/gm | | | Aluminum Fineness | 100 | |
| rasion, cury gin | | | 500-lb General Purpove Bombi | k: | |
| Specific Heat: col/gr//*C | (b) | | | | |
| At -5°C | | 0.23 | Plate Thickness, inches | Trials | % Ineri |
| Density, gm/cc | | 1.74 | 1 | 0 | |
| | | | 11/4 | • 6 | 100 |
| At 20 ⁰ C | | 0.31 | 11/2 | 6 | 33 |
| | | | - 194 | 0 | |
| Burning Rate: cm/sec | | | | | |
| cm/sec | | | Bomb Drop Test: (e) | | |
| Taermal Conductivity: | | h | | | . . |
| col/sec/cm/°C Density, gm/cc | (b) | 11×10^{-4} 1.73 | T7, 2000-lb Semi-Armer-Pierc | ing somb ve | Concrete: |
| Coefficient of Expansion: | | | Max Safe Drop, ft | | |
| Linear, %/*C | | | 500-ib General Purpose Somb | vs Concrete | : |
| Volume, %/*C | | | | Seal | Sea 1 |
| Volume, 307 G | | | | 4,000 | 5,000 |
| Hardness, Mohs' Scale: | | | Trials | 34 | 14 |
| | | | Unoffected | 32 | 14 |
| Young's Modelius | (b) | | Low Order | 0 | 0 |
| E', dynes/cm² | | 6.67×10^{10} | High Order | 5 | Ó |
| E, ib/inch ² | | 0.97 x 10 ⁶ | 1000-lb General Purpese Borni | h va Canzzata | • |
| Density, gm/cc | | 1.72 | | | Seal |
| · | | | Height, ft | | 5,000 |
| Compressive Strength: Ib/is | nch" (b) | 2340 | Trials | • | 24 |
| Density, gm/cc | <u>.</u> | 1.75 | Unoffected | | 23 |
| Vapor Prossure: | | | Low Order | | 0 |
| | Mercury | | High Order | | 1 |
| | | | | | |
| | | | | | فبني الأنفيون وتباليات مستردي |
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AMCP 706-177

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Tritonel, 80/20

| Fregmentation Tout: | | Shepod Charge Effectiveness, TNT = 100: | | |
|-----------------------------------------|-------|-----------------------------------------------------------------------------------|-------|--|
| 90 mm HE, M71 Projectile, Let WC-91: | 1 | Glass Cones Steel Cones | | |
| Density, gm/cc | 1.71 | Hole Volume | | |
| Charge Wt, Ib | 2.272 | Hole Depth | | |
| Tatul No. of Fragmants: | | Color: Gra | | |
| For TNT | 703 | | | |
| For Subject HE | 616 | Principel User: GP bombs | | |
| 3 inch HE, Mil2A1 Projectile, Let KC-5: | | | | |
| Density, gm/cc | 1.73 | | | |
| Charge 'v¥t, lb | 0.914 | | | |
| Tatal No. of Fragments: | | Method of Loading: Cas | + | |
| For TNT | 514 | | | |
| For Subject HE | 485 | | | |
| | | Looding Density: gm/cc 2.65-1.7 | 2 | |
| Fregment Velecity: ft/sec At 9 ft | 2460 | | | |
| At 2514 ft | 2380 | Storage: | | |
| Density, gm/cc | 1.72 | | | |
| | | Method Dry | , | |
| Sleet (Roletive to TNT): | (1) | Hazard Class (Quantity-Distance) Cl. | as 9 | |
| Air | | Compatibility Group Gro | Nup I | |
| Peak Pressure | 110 | | | |
| Impulse | 115 | Exudation | | |
| Energy | 119 | L | | |
| Air. Confined: | | Preparation: | | |
| Impulse | 130 | Tritonal is prepared by adding TNT ar | A | |
| | | aluminum separately to a steam-jacketed | | |
| Undur Weter: | 105 | kettle equipped with a stirrer. Heatin | ug of | |
| Peck Pressure | 105 | the kettle and mixing of the ingredient continued until all the TNT is welted. | | |
| Impulse | 118 | the viscosity of the mixture is conside | red | |
| Energy | 119 | satisfactory (about 85°C), the tritonal poured into projectiles or bombs the sa | 11 | |
| Underground. | | TNT. | | |
| Peak Pressure | 117 | | - | |
| Impulse | 127 | | | |
| Energy | 136 | | | |
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Tritonal, 80/20

AMCP 706-177

Origin:

The Addition of eluminum 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 cluminum in the TNT/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); end (4) the rate of detonation of cast charges is continuously decreased by additions of aluminum up to 40% (Ref j). For all practical purposes it is concluded that the addition of 18% to 20% aluminum to TNT improves its performance to a maximum. This conclusion is in agreement with that of British workers who measured performance of aluminized TNT-mixtures based on extensive Lead Block Test dats (Ref k).

Tritonal, consisting of 80% INT and 20% aluminum, was developed and standardized in the United States during World War II for use in bombs.

References:83

(a) L. C. Smith and E. H. Eyster, Physical Testing of Explosives, Part III, Miscellaneous Sensitivity Tests, Performance Tests, OSRD Report No. 5745, 27 December 1945.

(b) Philip C. Keenan and Dorothy Pipes, Table of Military High Explosives, 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 RuX/Wax Mixtures as a Substitute for Tetryl in Boosters</u>, NOL Memo 10, 303, 15 June 1949.

(c) Committee of Div 2 and 8, NDRC, Report on HEX and Tritonel, 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 TNT/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 High 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>, PATR No. 1380, Second Progress Report, 12 January 1944.

(j) L. S. Wise, Effect of Aluminum on the Rate 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.

Tritonel, EO/20

(1) Also see the following Picstinny Arsenal Technical Reports on Tritonal:

| ~ | - | | | | | For ch Off | 111 |
|--------------|------|----------|------|------|--------------|------------|-----|
| õ | 3 | <u>4</u> | 2 | 6 | 7 | 8 | |
| 1530 1560 | 1693 | 1444 | 1635 | 2000 | | ž | |
| 1560 | 2353 | | 1037 | 1956 | 1737 2127 | 21,38 | |



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Velter No. 448*

AMCP 706-177

| Composition: | | Malecular Weight: | 281 |
|---------------------------------------------------|------------|-----------------------------------|------|
| ж них | 70.0 | Oxygen Balance: | |
| Nitrocellulose (13.15% N) | 15.0 | CO ₂ % | -26 |
| Nitroglycerin | 10.7 | CO % | -0.5 |
| 2-Nitrodiphenylamine | 1.3 | Dunsity: gm/cc Pressed | 1.72 |
| Triacetin | 3.0 | Making Point: "C | |
| C/H Rotio | | Freezing Point: "C | |
| Impact Sensitivity, 2 Kg Wt: | · · · · · | Boiling Point: "C | |
| Bureau of Mines Appcratus, cm Somple Wt 20 mg | | Refrective Index, nº | |
| Picatinny Arsenal Apparatus, in. | | | |
| Sample Wt, mg | | n <mark>o</mark> | |
| | <u>_</u> | n o | |
| Friction Pandulum Test: | | Vacuum Stability Tett: | |
| Steel Shoe | Unaffected | cc/40 Hrs, at | |
| Fiber Shoe | Unaffected | 90°C | |
| Rifle Builet Impect Test: Trials | | - 100°C | 1.29 |
| % | | 120°C 29 hours | 11+ |
| Explosions | | 135°C | |
| Partials | | 150°C | |
| Burned | | . 200 Grem Bemb Send Test: | |
| Unaffected | | Sand, gm | 66.4 |
| Explosion Temperature: *C | | Sensitivity to Initian: | |
| Seconds, 0.1 (no cap used) | | Minimum Detonating Charge, gm. | |
| 1 | | Mercury Fulminate | |
| 5 | | Leod Azide | 0.30 |
| 10 | | Tetryi | |
| 15 20 | | Beilistic Mortur, % THT: | |
| | | Treuzi Test, % TNT: | |
| 75°C International Heat Test: % Loss in 48 Hrs | | Plate Dent Taut: Method | |
| 90 'C Heet Test: | | Condition | |
| % Loss, 1st 48 Hrs | 0.28 | Confined | |
| % Loss, 2nd 48 Hrs | 1.12 | Density, gm/cc | |
| Explosion in 100 Hrs | None | Brisance, % TNT | |
| Flammability Index; | <u></u> | Detenction Rate: Confinement | |
| Hygroscopicity: % | | Condition Charge Diameter, in. | |
| Veletility: | | Density, gm/cc | |

*See footnots on following page.

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Valter No. 448#

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| Beauter Sensitivity Test: | | Decomposition Equation: |
|------------------------------------------------------------------------------------|------------------------|---------------------------------------------------|
| Condition | | Oxygen, atoms/sec (Z/sec) |
| Tetryl, gm | | Heat, kilocalorie/mole |
| Wax, in. fer 50% Detonation | | (ΔH, kcai/mol) |
| Wax, gm | | Temperatule Range, *C |
| Density, gm/cc | | Phase |
| Hast of: | | Anner Plats Impact Test: |
| Combustion, cal/grn | 2359 | |
| Explosion, col/gm | 1,226 | 60 mm Morter Projectile: |
| Gas Volume, cc/gm | | 50% Inert, Velocity, ft/sec |
| Formation, cal/gm | | Aluminum Finaness |
| Fusion, cal/gm | | |
| | ····· | SOO-15 General Purpose Bemba: |
| Compression at Rupture: \$ | 8.26 | Plate Thickness, inches |
| Work to Produce Rupture: | | |
| ft-lb/inch ³ | 9.62 | 1% |
| It-10/10c0 | 9.0z | 134 |
| | | 1 |
| Bu-st-s Badas | | 1% |
| Surning Rote: cm/sec | | |
| | | Bomb Drop Test: |
| Thermal Conductivity: cal/sec/cm/*C | | T7, 2000-16 Semi-Anner-Plercing Bomb vs Concreto: |
| | | |
| Coefficient of Exponsion: | | Max Safe Drop, ft |
| Linear, %/*C | | 500-lb General Purpose Somb vs Concrute: |
| • • • | | |
| Volume, %/*C | | Height, ft |
| | | Trials |
| Hardnass, Mahs' Scala: | | Unoffected |
| | | Low Order |
| Young's Medulue: | × 10 | High Order |
| E', dynes/cm³ | 0.24×10^{10} | |
| E, lb/inct/* | 0.35 x 10 ⁵ | 1000-lb General Purpose Bemb vs Constats: |
| Density, gm/cc | | |
| | | Height, ft |
| Comprussive Strength: Ib/inch ³ | 2720 | Triols |
| | | Unaffected |
| Vapor Pressure: | | Low Order |
| *C mm Mercury | | High Order |
| | | |
| *Name assigned by Dr. Mark M. of PA; based on original day James H. Veltman. | | |

Veltex No. 448

AMCP 706-177

| Fregmentation Test: | Shaped Charge Effectiveness, TNT | Shaped Charge Effectiveness, TNT = 100: | | | |
|----------------------------------------|-------------------------------------|-----------------------------------------|--|--|--|
| 90 mm HE, M71 Projectilo, Let WC-91: | Glass Cones St | ael Cones | | | |
| Density, gm/cc | Hole Volume | | | | |
| Charge Wt, Ib | Hole Depth | | | | |
| Total No. of Fragments: | Caleri | | | | |
| For TNT | Centr | Orange | | | |
| For Subject HE | Principui Uses: High machanics | at rength | | | |
| 3 inch HE, M42A1 Projectile, Let KC-5: | machinable exp | losive | | | |
| Density, gm/cc | | | | | |
| Charge Wt, Ib | | | | | |
| Total No. of Fragments: | Marked of London | Pressed | | | |
| For TNT | Method of Londing: | Pressed | | | |
| For Subject HE | | | | | |
| | Looding Density: gm/cc | | | | |
| fregment Valecity: ft/sec | At 6,700 psi | 1.72 | | | |
| At 9 ft At 25½ ft | Storage: | | | | |
| Density, gm/cc | Method | Dry | | | |
| liest (Koletive to TNT): | Hazard Class (Quantity-Distance | · | | | |
| Air: | Compatibility Group | | | | |
| Peak Pressure | Companying Group | | | | |
| Impulse | Exudation | None | | | |
| Energy | Machinability | Excellen | | | |
| Air, Confined: Impulse | | | | | |
| Under Weter: Peak Pressure | | | | | |
| Impulse | | | | | |
| Energy | | | | | |
| Underground: Peak Pressure | | • | | | |
| impulse | | | | | |
| Energy | | | | | |
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AMCP 706-177

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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 agitator. Add 5.85 gm of 2-nitrodiphen/lamine and agitate for several minutes to obtain dispersion. Then add 93.7 gm of water-wet nitrocellulose (dry weight 67.5 gm) in shell portions. Raise the temperature to 48° C and maintain this temperature, but continue the agitation. A mixture of 48.2 gm of itroglycerin and 13.5 gm of triacetin is added over a 5-minute period, with the mixing continuing for an additional 10 minutes at 48° C. The HMX (350 gm) is added over a 5-minute period with agitation continued for 30 minutes at 48° C. The slurry is croled to room temperature and filtered. The filter cake is dried to a moisture conton 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 colloid is then preheated on a heat table at 66° C. Increments of 25 gm each are pressed at 6700 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 Finatiany 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 Suize of Switzerland, France and Spain, but for which the composition was not reported (Ref a). Compositions similar to Valtex No. 448 and containing 60% to 80% HMX, with either nitroglycerin or writhylanglycol dimitrate 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, <u>Holtex-Hispano Suize Emplosive</u>,
 4 May 1955.

84See footnote 1, page 10.

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