COMPOSITION B

1. GENERAL PROPERTIES

1.1 Chemical and Physical Description. Composition B (Comp B), a mixture of 60 wt% RDX and 40 wt% TNT, with or without a wax desensitizer, is yellow-brown. Mixtures of RDX and TNT are generally called cyclotols in the United States, Hexolite in France, Füllpulver in Germany, Tritolite in Italy, Tritolita in Spain, and Hexotol in Sweden.

Comp B desensitized with 1 wt% wax is available in grades A and B. Grade A is more fluid than Grade B when molten. Comp B-3 contains no desensitizer. It is more viscous than Grade A or B when molten because its median RDX particle diameter is smaller.

1.2 Common Use. Comp B is used as the explosive fill in almost all types of explosive ordnance.

1.3 Toxicity.[1] The toxicity of Comp B is like that of RDX and TNT.

Workers who inhaled RDX dust for several months have become unconscious and have suffered loss of reflexes. The suggested maximum permissible airborne concentration is 1.5 mg/m^3.

Inhaled TNT vapor or dust may irritate mucous membranes and cause sneezing, coughing, and sore throat. TNT may produce toxic hepatitis and aplastic anemia, and it yellows the exposed skin, hair, and nails of workers. Dermatitis, erythema, papules, and itchy eczema can be severe. Ingestion of 1-2 g of TNT is estimated to be an acute fatal dose to humans. The suggested maximum permissible airborne dust concentration is 0.5 mg/m^3.

2. MANUFACTURE AND PROCUREMENT

2.1 Manufacture. Comp B-type explosives, including cyclotols, are manufactured from TNT and water-wet RDX. The TNT is melted in a steam-jacketed kettle equipped with a stirrer and is brought to about 100°C. The wet RDX is added slowly. Heating and stirring are continued until most of the water is evaporated. The appropriate desensitizing wax or other additive is then thoroughly mixed with the other ingredients. After cooling to satisfactory fluidity, the Comp B is cast into strips or chips. The chips are shipped to an ordnance plant, remelted, and cast into ammunition or into desired shapes. During this melting, other additives may be introduced. To increase the density of cast charges, a vacuum may be applied to the molten Comp B before casting.

2.2 Procurement. Comp B is purchased from the US Army Armament Readiness Command under military specification MIL-C-401C, dated May 15, 1968, or, as Comp B-3, under MIL-C-45113, dated June 19, 1958.

2.3 Shipping.[2] Comp B is shipped as a Class A explosive.

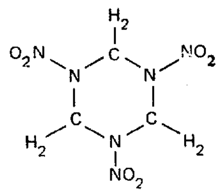
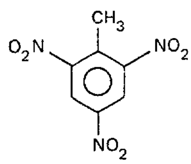
2.4 Storage.[3] Comp B is stored in Compatibility Group D, Storage Class 1.1.

3. CHEMICAL PROPERTIES

3.1 Composition.

	Comp B, Grades A and B		Comp B-3	
Constituent	Weight Percent	Volume Percent	Weight Percent	Volume Percent
RDX	59.5	56.9	60.0	57.8
TNT	39.5	41.2	40.0	42.2
Wax	1.0	1.9	0.0	0.0

3.2 Molecular Weight.

Constituent	Structure	Molecular Weight
RDX	 $C_3H_6N_6O_6$	222.13
TNT	 $C_7H_5N_3O_6$	227.13
Wax	$CH_3(CH_2)_n CH_3$	$30.07 + (14.02)_n$

3.3 Solubility.[4] The solubility is that of the components RDX and TNT.

Solvent	Grams of RDX Dissolved/100 g of Solvent 20°C	40°C	60°C
Acetic acid			
99.6%	0.46	0.56	1.22
71.0%	0.22	0.37	0.74
Acetone	6.81	10.34	----
Isoamyl alcohol	0.026	0.060	0.210
Benzene	0.045	0.085	0.195
Chlorobenzene	0.33	0.554	---
Cyclohexanone	4.94	9.20	13.9
Dimethylformamide	---	41.5	60.6
Ethanol	0.12	0.24	0.58
Methyl acetate	2.9	4.1	---
Methylcyclohexanone	6.81	10.34	---
Methyl ethyl ketone	3.23	---	---
Toluene	0.020	0.050	0.125
Trichloroethylene	0.20	0.24	---
Water	0.005	0.0127	0.03

Solvent	Grams of TNT Dissolved/100 g of Solvent 20°C	40°C	60°C
Acetone	109.0	228.0	600.0
Benzene	67.0	180.0	478.0
Butyl carbinol acetate	24.0	----	----
Carbon disulfide	0.48	1.53	----
Carbon tetrachloride	0.65	1.75	6.90
Chlorobenzene	33.9	----	---
Chloroform	19.0	66.0	302.
Diethyl ether	3.29	---	---
Ethanol (95%)	1.23	2.92	8.30
Ethylene chloride	18.7	----	----
Hexane	0.16	---	----
Methyl acetate	72.1	---	----
Toluene	55.0	130.0	367.0
Trichloroethylene	3.04	---	---
Water	0.0130	0.0285	0.0675

4. PHYSICAL PROPERTIES

4.2 Density

Material	Theoretical Density (g/cm³)	Density of Typical Casting (g/cm³)	
		Open Melt	Vacuum Melt
Comp B, Grades A and B	1.737	1.68-1.70	1.715-1.720
Comp B-3	1.750	---	1.725-1.730

4.3 Infrared Spectrum. See Fig. 1.

5. THERMAL PROPERTIES

5.1 Phase Change.

Type	Temperature (°C)	Latent Heat (cal/g)
Solid-to-slurry	79	14.1

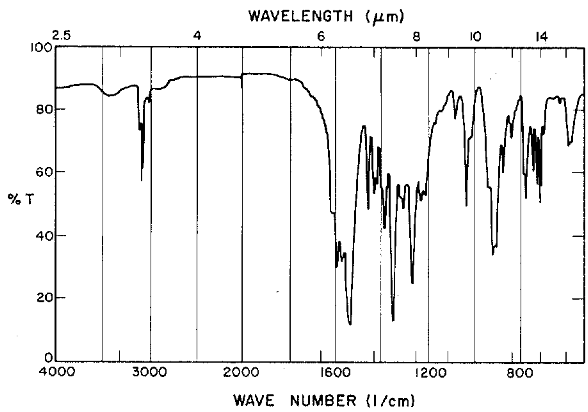


Fig. 1. Infrared spectrum.

5.3 Heat Capacity.

Heat Capacity at Constant Pressure (cal/g-°C)	Temperature Range (°C)
$0.234 + 1.03 \times 10^{-3}\ T$	$7 < T < 76$

5.4 Thermal Conductivity.

Density (g/cm^3)	Conductivity (cal/s-cm-°C)
1.730	5.23×10^{-4}

5.5 Coefficient of Thermal Expansion.

Coefficient of Expansion (1/°C)	Temperature Range (° C)
5.46×10^{-5}	$6 < T < 25$

5.6 Heats of Combustion and Formation.[5]

Constituent	ΔH_c° (kcal/mole)	ΔH_f° (kcal/mole)
TNT	-817.2	-12.0
RDX	-501.8	14.7

5.7 Thermal Decomposition Kinetics.[6]

	TNT	RDX
Decomposition energy	300 cal/g	500 cal/g
Activation energy	34.4 kcal/mole	47.1 kcal/mole
Pre-exponential factor	$2.51 \times 10^{11}/s$	$2.02 \times 10^{18}/s$

5.8 Other Thermal Stability Test Results.

Test	Results
Vacuum	0.2-0.6 ml/g of gas evolved after 48 h at 120°C
DTA and pyrolysis	See Fig. 2
Critical temperature, Tm	214°C
Charge radius, a	3.0 mm

6. DETONATION PROPERTIES

6.1 Detonation Velocity.[7]

Effect of Charge Radius

Charge radius affects the detonation velocity of unconfined Grade A Comp B, cast to a density of 1.700 g/cm³, as follows.

$$D(R) = 7.859[(1 - 2.84 \times 10^{-2}/R) - 5.51 \times 10^{-2}/R(R - 1.94)]\,,$$

where D = detonation velocity in millimeters per microsecond

and R = charge radius in millimeters.

The experimentally determined failure diameter is 4.28 mm.

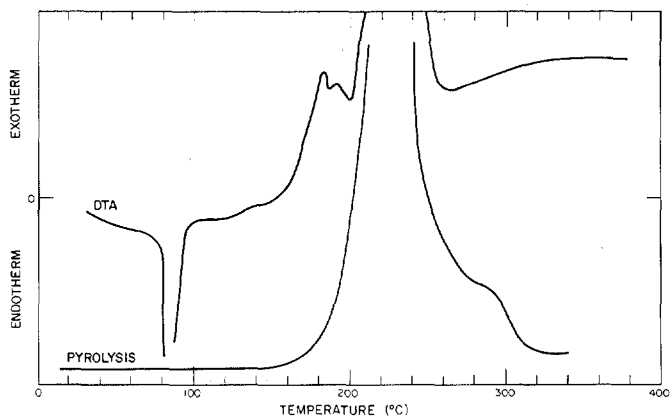


Fig. 2. Comp B DTA and pyrolysis test results.

6.2 Detonation Pressure.[8]

Grade A Comp B (Weight Percent RDX)	Density (g/cm^3)	Detonation Velocity ($mm/\mu s$)	Detonation Pressure (GPa)
64.0	1.713	8.018	29.22

6.3 Cylinder Test Results.

Density[a] (g/cm^3)	Detonation Velocity ($mm/\mu s$)	Cylinder Wall Velocity ($mm/\mu s$) at	
		$R-R_o$ = 5 mm	$R-R_o$ = 19 mm
1.700[b]	7.915	1.377	1.625
1.715	7.911	1.378	1.628

[a]Grade A Comp B.
[b]Scaled from a 4-in.-diam shot.

6.4 Plate Dent Test Results.[9]

Charge Diameter (mm)	Weight Percent RDX	Density (g/cm^3)	Dent Depth (mm)	Charge Height (mm)
41.3	60.7	1.730	8.64	203
41.3	64.0	1.714	8.47	203

7. SHOCK INITIATION PROPERTIES

7.1 Gap Test Results.[10]

Type	Density (g/cm^3)	Weight Percent RDX	G_{50} (mm)	L_{95} (mm)
		Large Scale		
Comp B-3	1.727	60.0	50.34	0.81
Grade A Comp B	1.710	64.0	45.69	0.45
Grade A Comp B	1.714	64.0	45.18	0.08
		Small Scale		
Comp B-3	1.720	60.0	1.22	---
Grade A Comp B	1.710	---	1.5	0.08

7.2 Wedge Test Results.[11]

Density (g/cm^3)	Distance, x*, to Detonation (mm)	Pressure Range[a] (kbar)
1.72	$2100\ P^{-1.34}$,	$40 < P < 100$

where P = pressure in kilobars.[a]

[a]Users should note that this is the only wedge data fit in this volume where pressure is in units of kilobars.

7.3 Shock Hugoniots.[12,13]

Comp B-3 Density (g/cm^3)	Shock Hugoniot (mm/μs)	Particle Velocity Range (mm/μs)
1.680	$U_s = 2.71 + 1.86\,U_p$,	$0 < U_p < 1.0$
1.70	$U_s = 3.03 + 1.73\,U_p$,	$0 < U_p < 1.0$

where U_s = shock velocity
and U_p = particle velocity.

7.4 Minimum Priming Charge.[10]

Density (g/cm^3)	W_{50} (mg of XTX 8003)	L_{95} ($\pm$ log mg)
1.727[a]	245	0.070
1.725[b]	623	0.027

[a]Comp B-3.
[b]Grade A Comp B.

7.5 Detonation Failure Thickness.[10]

Density (g/cm^3)	Failure Thickness (mm)	L_{95} (mm)
1.729[a]	0.785	0.086
1.729[a]	0.881	0.297
1.727[a]	0.805	0.081
1.727[a]	0.813	0.051
1.713[b]	1.42	0.07

[a]Comp B-3
[b]Grade A Comp B.

8. SENSITIVITY

8.1 Drop Weight Impact Height

Tool Type	H_{50} (cm)
12	59
12B	109

8.2 Large-Scale Drop Test Height.

Density (g/cm^3)	H_{50} (ft)	Reaction
1.725	85	Partial

8.3 Skid Test Results.

Density (g/cm^3)	Impact Angle (degrees)	Target Surface	H_{50} (ft)	Reaction Overpressure (psi)
1.727	15	Sand and epoxy	9.8	< 0.5

8.4 Susan Test Results.[14]

Projectile Impact Velocity (ft/s)	Relative Energy Release (%)
600	0
800	5
1000	20
1200	30
1400	38

9. MECHANICAL PROPERTIES

9.2 Tensile Strength and Modulus.

Ultimate Tensile Strength (psi)
135-150

9.3 Compressive Strength and Modulus.

Temperature (°C)	Ultimate Compressive Strength (psi)	Compressive Modulus (psi x 10^{-6})
50	1400 ± 96	0.63 ± 0.1
0	1860 ± 200	2.40 ± 0.3
-40	2150 ± 280	2.50 ± 0.2

REFERENCES

1. C. R. Buck and S. E. Wilson, Jr., US Army report USEHA-32-049 (1975).

2. *Code of Federal Regulations, 49, Transportation Parts 100-199, Rev. 12-1-76* (Office of the Federal Register, General Services Administration, Washington, DC, 1976).

3. US Army Materiel Command, Regulation No. AMCR 385-100 (1977).

4. A. Seidell, *Solubilities of Organic Compounds,* 3rd Ed., Vol. II, (D. Van Nostrand Co., Inc., New York, 1941).

5. Prince E. Rouse, Jr., Journal of Chemical Engineering Data **21**, 16-20 (1976).

6. R. N. Rogers, Thermochimica Acta **11**, 131-139 (1975).

7. A. W. Campbell and Ray Engelke, *Proceedings—Sixth Symposium (International) on Detonation, Coronado, California, August 24-27, 1976* (Office of Naval Research, Department of the Navy, ACR-221, 1976), pp. 642-652.

8. W. E. Deal, Journal of Chemical Physics **27**, 796-800 (1957).

9. L. C. Smith, Explosivstoffe **15**, 106-130 (1967).

10. Manuel J. Urizar, Suzanne W. Peterson, and Louis C. Smith, Los Alamos Scientific Laboratory report LA-7193-MS (April 1978).

11. J. B. Ramsay and A. Popolato, *Proceedings—Fourth Symposium (International) on Detonation, White Oak, Maryland, October 12-15, 1965* (Office of Naval Research, Department of the Navy, ACR-126, 1965), pp. 233-238.

12. N. L. Coleburn and T. P. Liddiard, Journal of Chemical Physics **44**, 1929-1936 (1966).

13. V. M. Boyle, R. L. Jameson, and M. Sultanoff, *Proceedings—Fourth Symposium (International) on Detonation, White Oak, Maryland, October 12-15, 1965* (Office of Naval Research, Department of the Navy, ACR-126, 1965), pp. 241-247.

14. L. G. Green and G. D. Dorough, *Proceedings—Fourth Symposium (International) on Detonation, White Oak, Maryland, October 12-15, 1965* (Office of Naval Research, Department of the Navy, ACR-126, 1965), pp. 477-486.