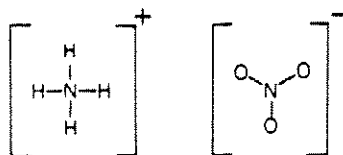


Ref

1. NAME: **Ammonium Nitrate**

2. STRUCTURE:



Empirical Formula:  $\text{H}_4\text{N}_2\text{O}_3$

3. PHYSICAL PROPERTIES:

Physical State: Crystalline Solid	1
Color: Colorless	1
Molecular Weight: 0.080 5 kg/mol	1,2
Density ( $\rho$ ): 1.725 Mg/m <sup>3</sup> (TMD)	1
1.72 Mg/m <sup>3</sup> (nominal)	1
For $\rho$ of the polymorphs see T-04 in Section 10	
M.P.: 442 K (169°C)	1
442.8 K (169.6°C)	1,3
442.8 to 443.1 (169.6 to 169.9°C)	2
B.P.: ~483 K at 1.46 kPa (~210°C at 11 mm Hg)	2
d 483 K (d 210°C)	1
Solubility(s-sol., sl-slightly-sol., i-insol., d-decomposes):	
s - H <sub>2</sub> O (118.3 g/100 ml at 273 K; 871 g/100 ml at 373 K), DMFA, acetone, NH <sub>3</sub>	1,3
sl - ethanol (3.8 g/100 ml at 293 K), methanol (17.1 g/100 ml at 293 K), pyridine	1,3
i - acetone, ethyl acetate, ethyl ether	1
Hardness: 1.1 (Mohs Scale)	2
Hygroscopicity: see T-01 in Section 10	

	<u>Ref</u>
4. THERMAL PROPERTIES:	
Heat of Formation ( $\Delta H_f^\circ$ ): -365.1 kJ/mol (-87.27 kcal/mol)	1,3,5
Heat of Fusion ( $\Delta H_m^\circ$ ): 6.106 kJ/mol (18.23 cal/g)	2
Heat of Combustion ( $\Delta H_c^\circ$ ): 206.7 kJ/mol (49.4 kcal/mol)	2
Heat of Sublimation ( $\Delta H_s^\circ$ ): 174.9 kJ/mol (41.8 kcal/mol)	2
Heat of Explosion ( $\Delta H_{ex}^\circ$ ): 128.88 kJ/mol (1601 kJ/kg)	4
212 kJ/mol (630 cal/g): H <sub>2</sub> O(l)	2
116.64 kJ/mol (346.3 cal/g): H <sub>2</sub> O(g)	2
Heats of Transition ( $\Delta H_t$ ) and Transition Temperatures:	
III( $\gamma$ ) $\rightarrow$ II( $\delta$ ): 1.297 MJ/mol (310 kcal/mol) at 357 K (84°C)	2
II( $\delta$ ) $\rightarrow$ I( $\epsilon$ ): 4.10 MJ/mol (979 kcal/mol) at 398 K (125°C)	2
see also T-04 in Section 10	
Heat Capacity ( $C_p$ ): 1.67 kJ/(kg·K) at 273 K (0.40 cal/g·°C at 0°C)	1
see also T-02 in Section 10	
Thermal Conductivity (k):	
0.238 W/(m·K) (0.205 kcal/m/h/°C)	2
0.121 to 0.163 W/(m·K) (2.9 to 3.9 x 10 <sup>-4</sup> cal/cm·sec·°C)	1
Coefficient of Thermal Cubical Expansion ( $\beta$ ):	
982 x 10 <sup>-6</sup> /K at 293 K	1
see also T-03 in Section 10	
Thermal Stability:	
DTA: see F-01 in Section 9	
TGA: see F-02 in Section 9	
Heat Test at 373 K (100°C): 0.74% loss in 1st 48 h	2
0.13% loss in 2nd 48 h	2
no explosion in 100 h	2
Vacuum:	
0.02 to 0.20 mm <sup>3</sup> /kg for 40 h at 393 K (0.1 to 1.0 cc/5 g in 40 hrs at 120°C)	2
0.06 mm <sup>3</sup> /kg for 40 h at 423 K (0.3 cc/5 g in 40 hrs at 150°C)	2

Ref

5. CRYSTAL AND OPTICAL PROPERTIES:

Crystalline Forms, Refractive Indexes, Unit Cell Dimensions:  
see T-04 in Section 10

6. ELECTRICAL PROPERTIES:

Magnetic Susceptibility (K):  $-336 \text{ m} \cdot \text{kg} \cdot \text{s}$  ( $-33.6 \times 10^{-6} \text{ cgs}$ ) 3  
Dielectric Constant ( $\epsilon$ ) at 9.54 GHz, room temp.,  $\rho$  1.6 to 1.79:  $\sim 7.1$  1

7. EXPLOSIVE AND SENSITIVITY PROPERTIES:

Detonation Velocity:  $\sim 1.5 \text{ km/s}$  at  $\rho$  of  $\sim 0.7$  1  
3.49 km/s at  $\rho$  of 0.82 (in paper tubes) 1  
5.27 km/s at  $\rho$  of 1.30 (in paper tubes) 1  
see also T-05 in Section 10

Lead Block Expansion Test:  $0.018 \text{ m}^3/\text{kg}$  ( $180 \text{ cm}^3/10 \text{ g}$ ) 4

Brisance:

Lead Cylinder Compression Test (TNT = 100): 54% 2  
200 g Sand Test: Only Partial Explosion 2

Impact Sensitivity:

1.36 m with a 2.5 kg weight (sandpaper) 1  
>3.20 m with a 2.5 kg weight (roughened steel) 1  
BuMines: no reaction with 2.0 kg weight 2  
PA: 0.79 m (31 in.) at 298 K ( $25^\circ\text{C}$ ) with 2.0 kg weight 2  
0.69 m (27 in.) at 398 K ( $100^\circ\text{C}$ ) with 2.0 kg weight 2  
0.69 m (27 in.) at 423 K ( $150^\circ\text{C}$ ) with 2.0 kg weight 2  
0.30 m (12 in.) at 448 K ( $175^\circ\text{C}$ ) with 2.0 kg weight 2

Friction Pendulum Test: unaffected with steel shoe 2

Explosion Temp.: 598 K ( $325^\circ\text{C}$ ) in 3 s 2

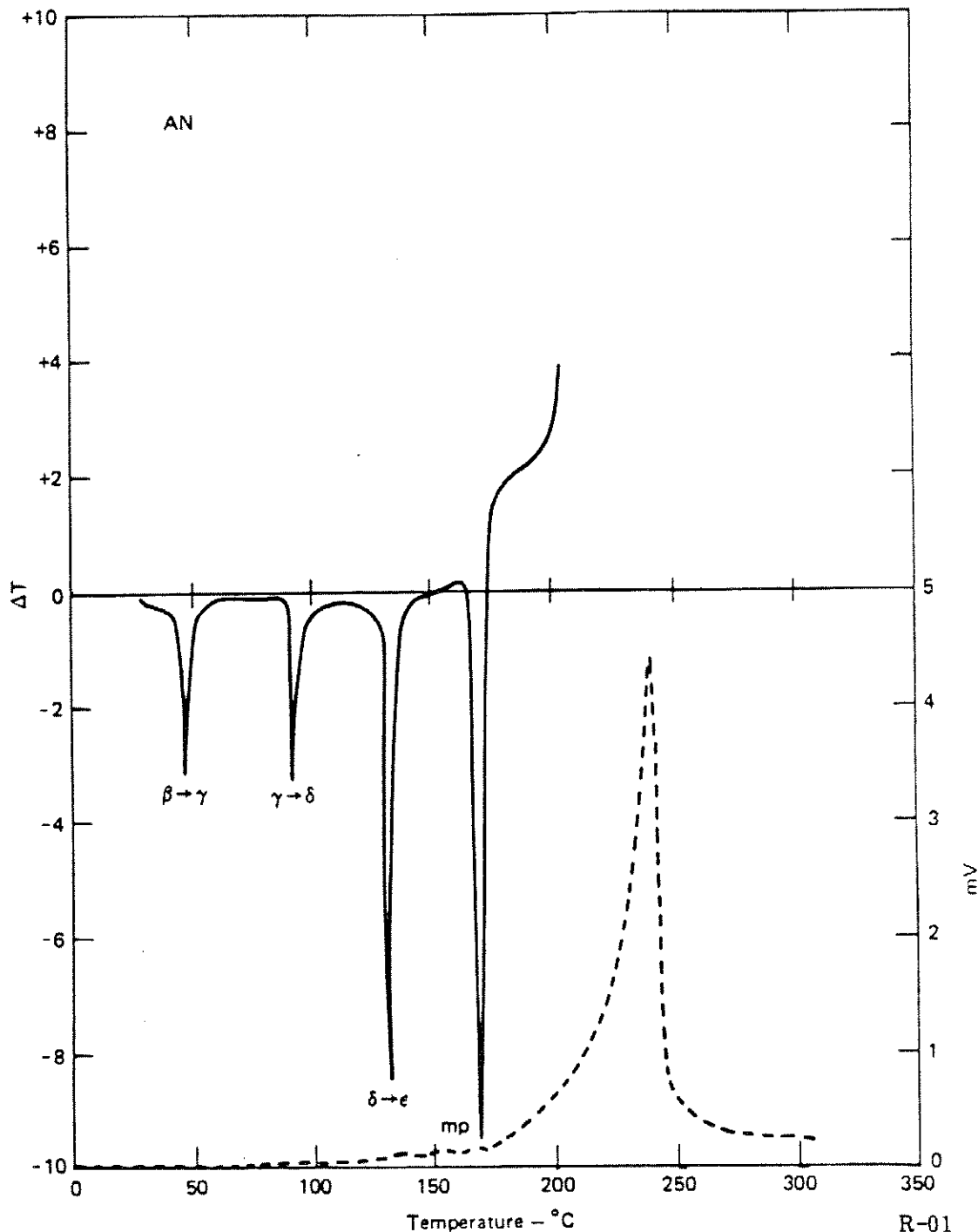
Critical Diameter ( $d_c$ ): see T-06 in Section 10

8. HAZARDS:

Toxicity: Low 1

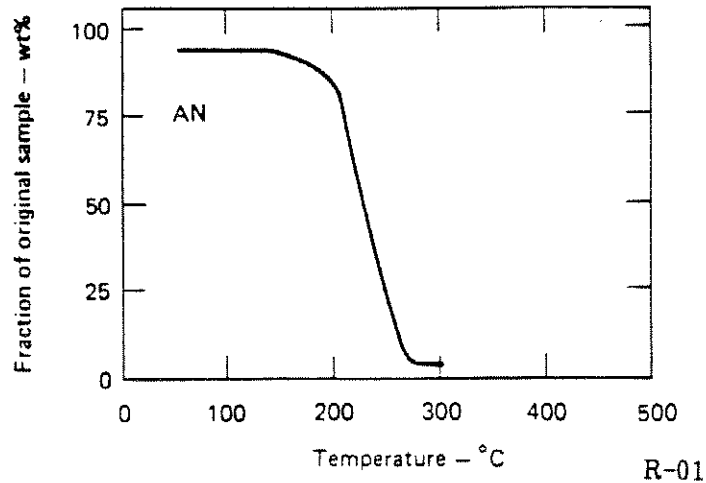
DOT Hazard Classification: Oxidizer 6

9. FIGURES:



F-01. DTA curve (solid line) and pyrolysis (thermal conductivity) curve (dashed line) for ammonium nitrate.

9. FIGURES (Cont'd):



F-02. TGA curve for ammonium nitrate

10. TABLES:

T-01. Hygroscopicity of AN			
Exposure, days	1	2	3
% Gain at 52% RH	0.2	0.2	0.2
at 76% RH	14.1	26.1	29.1
at 90% RH	32	62	84
Exposure, days	6	7	8
% Gain at 52% RH	0.2	0.2	0.2
at 76% RH	69.1	74.1	78.4
at 90% RH	133	145	156

R-02

## 10. TABLES (Cont'd):

T-02. Heat Capacity of AN	
Temperature	Heat Capacity ( $C_p$ )
73 K (-200°C)	0.3 kJ/kg·K (0.07 cal/gm/°C)
123 K (-150°C)	0.79 kJ/kg·K (0.19 cal/gm/°C)
173 K (-100°C)	1.26 kJ/kg·K (0.30 cal/gm/°C)
193 K (-80°C)	1.46 kJ/kg·K (0.35 cal/gm/°C)
223 K (-50°C)	1.54 kJ/kg·K (0.36 cal/gm/°C)
273 K (0°C)	1.67 kJ/kg·K (0.40 cal/gm/°C)
323 K (50°C)	1.732 kJ/kg·K (0.414 cal/gm/°C)
373 K (100°C)	1.791 kJ/kg·K (0.428 cal/gm/°C)

R-02

T-03. Coefficient of Thermal Cubical Expansion of AN	
Temperature	$\beta \times 10^6$ ( $\mu\text{m}/\text{m}\cdot\text{K}$ )
213 K (-60°C)	677
253 K (-20°C)	852
273 K (0°C)	920
291 K (18°C)	978
293 K (20°C)	982
333 K (60°C)	1069
373 K (100°C)	1113

R-02

10. TABLES (Cont'd):

T-04. Crystallographic and Optical Properties of AN <sup>a</sup>						
Material	Polymorph	Unit cell dimensions <sup>b</sup> (A (10 <sup>-1</sup> nm)) and angles	Crystal class	Space group	Refractive index (n)	Molecular refraction (R)
AN (125-169.6°C)	I(ε) ρ=1.58-1.61	a=4.37	Cubic	Pm3m	1.530	
(84-125°C)	II(δ) ρ=1.64-1.67	a=5.72 c=4.93	Tetragonal	P4 <sub>2</sub> 1m or P4/mbm	ω=1.509 ε=1.585	
(32.3 to 84.1°C)	III(γ) ρ=1.64-1.66	a=7.72 b=5.85 c=7.16	Orthorhombic	Pnma	α=1.463 β=1.543 γ=1.600	
(-18 to 32.3°C)	IV(β) ρ=1.71-1.75	a=5.75 b=5.44 c=4.93	Orthorhombic	Pmmn		
(-18 to -150°C)	V(α) ρ=1.70-1.72	a=8.0 c=9.83	Tetragonal	P4 <sub>2</sub>	α=1.493 γ=1.623	

R-01

<sup>a</sup> Refractive indexes and molecular refractions are at 5893 Å and 25°C (589.3 nm and 298 K) unless otherwise stated; 10 Å = 1 nm.

<sup>b</sup> Unit cell dimensions are rounded to 0.01Å.

10. TABLES (Cont'd):

T-05. Rates of Detonation of Pure AN						
Rate, m/sec	Density, g/cc	Charge dia, mm	Container	Initiation by	Charge temp, °C	Investigator
				No 8 cap plus:		
1140	0.68-0.73	26.2	Shelby tube	75 g tetryl	15	Gawthrop
1560	0.68-0.73	26.2	53.5 cm long, 4.85mm wall	75 g tetryl	71	Gawthrop
1230	0.69	50	Steel tube	100 g PA	Room	Kast
1310	0.84	25.	Steel tube	50 g tetryl	Room	Kast
1470	0.83	26	Steel tube	60 g tetryl	Room	Kast
1530	0.79	80	Steel tube	100 g PA	Room	Kast
1550	0.88	80	Steel tube	100 g PA	Room	Kast
1820	0.84	100	Steel tube	200 g PA	Room	Kast
1850	0.82	26.2	Shelby tube	100 g tetryl	Room	Perrott
1920	0.64	100	Steel tube	100 g PA	Room	Kast
2440	--	50	Lead tube	100 g PA	Room	Aufschläger
2700	0.98	80	Steel tube	250 g tetryl	Room	Kast
1200- 1500- 2000- 2500- 1500 3000	When incompletely decomposed					Stettbacher
	When completely decomposed					Stettbacher
	Calculated value for incomplete detonation					Kast
	Calculated value for complete detonation					Kast

R-02

T-06. Critical Diameter ( $d_c$ ) of AN			
Explosive	Density, $\rho$ [g/cm <sup>3</sup> (Mg/m <sup>3</sup> )]	Critical diam ( $d_c$ ) (mm)	Conditions
AN	low-density ~0.95	=100 ~12.7	Confined in steel tube Encased in paper tube, poor reproducibility
(pressed)	1.4	no detonation	100-mm-diam charge confined in glass tubing
	1.61	no detonation	36.5-mm-diam charge confined in 11-mm- thick steel tube

R-01

Ref

12. MILITARY SPECIFICATIONS:

MIL-A-50460A

1

13. REFERENCES:

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- R-06. 49 Transportation Code of Federal Regulations (CFR), Rev. Oct 1, 1981, Chapter I, Paragraph 172.101, U.S. Government Printing Office, Washington, DC.

Data Compiled by H. J. Hoffman