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THE EFFECT OF AGING ON THE PROPERTIES OF COMPOSITION B

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Impact sensitivity	Thermogravimetric analysis	
Friction sensitivity	Autoignition temperature	
Electrostatic sensitivity	Large scale gap test	
Explosion temperature	Detonation velocity	

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Selected safety and characterization tests were conducted on Composition B from a 31 year old lot in order to evaluate the effect of aging on the properties of the explosive. The results of the tests are compared to those for Composition B from recent lots. The tests included impact sensitivity, friction sensitivity, electrostatic sensitivity, explosion temperature, differential thermal analysis, thermogravimetric analysis, autoignition temperature,

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20. ABSTRACT (Cont)

large scale gap test, growth characteristics, and detonation velocity. The data showed that no significant changes have occurred to the explosive since it was manufactured in 1952. The only change noted was that the aged Composition B exhibited a slightly greater irreversible volume change than the Composition B from a recently manufactured lot.

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INTRODUCTION

The Energetic Materials Division, Large Caliber Weapon Systems Laboratory, United States Army Armament Research and Development Center (ARDC), Dover, NJ, was tasked by the Artillery/Energetic Materials Division, AMCCOM to evaluate the effect of aging on the properties of Composition (Comp) B from a 31 year old lot, HOL 4-330, and to determine whether the explosive could be used or should be destroyed. The subject lot was produced on or about 14 June 1952 and more than 20,000 lbs of the explosive are still in storage at Louisiana Army Ammunition Plant.

The following safety and characterization tests were performed in accordance with the procedures described in Volume IV "Joint Service Safety Performance Manual for Qualification of Explosives for Military Use" (ref 1) and the TTCP Panel 0-2 (Explosives), Working Group on Sensitivity, "Manual of Sensitiveness Tests" (ref 2).

1. Impact sensitivity

    a. Full firing curve

    b. 50% initiation height

    c. 10% initiation height

2. Friction sensitivity

3. Electrostatic sensitivity

4. Thermal sensitivity

    a. Explosion temperature

    b. Differential thermal analysis (DTA)

    c. Thermogravimetric analysis (TGA)

    d. Autoignition temperature

    e. Shelf-life

5. Shock sensitivity (large-scale gap test)

6. Physical stability (irreversible growth)

7. Detonation velocity

The tests were conducted on samples from one 50-pound box of Comp B. Two recent lots of Comp B were tested concurrently to generate comparative data. Samples from Lot HOL 053-97, produced in 1974, were used for tests (1) through (4) and material from Lot HOL 79E-100-696, made in 1979, was used for tests (5)

through (7). The explosives were ground into powder by means of a Wiley mill for tests (1) through (4). For tests (5) through (7), the explosives were cast into the assemblies or a mold.

TEST PROCEDURES

Impact Sensitivity

The impact sensitivity test was conducted to compare the relative impact sensitivity of Comp B from the subject lot to a recent lot. The tests were performed with the Explosives Research Laboratory (ERL), sometimes called the Naval Ordnance Laboratory (NOL), Type 12 impact tester. The apparatus uses a 2.5 kg steel drop weight with a 30 mg sample resting on sandpaper between two steel anvils. A detailed description of the apparatus is contained in reference 2.

A full firing curve, as well as the drop heights corresponding to the 50% and 10% probability of initiation, were used as a measure of impact sensitivity. The firing curve was determined by the rundown method, using 20 trials at each height. The 50% initiation point was determined by means of the Bruceton up-and-down method. The 10% initiation point was the minimum height which resulted in initiation of the sample in at least one of ten trials. The amount of the test sample consumed during a run varied from a low level, as evidenced by a very slight sound or a slight burn mark, to complete burning or detonation. The criterion for initiation in this study was any evidence of burning or detonation observed during impact or in the post-test examination of the sample.

Friction Sensitivity

The ARDC large-scale friction pendulum tester was used to determine whether the aged Comp B passed the friction requirement. The tester consists of a fixed steel anvil and a weighted pendulum with either a steel or a hard fiber-faced shoe. In this test, the sample was placed on the anvil and subjected to a series of glancing blows by the shoe attached to the pendulum rod. The first series of tests was conducted with the steel shoe, the most severe condition. A test consisted of ten consecutive trials. The reaction that could occur was characterized as either unaffected, crackling, sparking, burning, or explosion. The material passes the friction test if no reaction occurred in the ten trials with the steel shoe. If a reaction occurred, the trials with the steel shoe were stopped. The steel shoe was then replaced with the fiber shoe and the test was continued. The material also satisfies the qualification criterion if there was no more than an almost inaudible local crackling in ten trials with the fiber shoe, regardless of its behavior when subjected to the action of the steel shoe. A detailed description of the tester and the test procedure are given in reference 2.

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Electrostatic Sensitivity

An approaching electrode apparatus (ref 3) was used to determine whether or not the aged Comp B passed the electrostatic sensitivity requirement. The apparatus consists of a high voltage power supply, a capacitor-charging circuit, and an approaching-electrode assembly. In this test, the explosive powder (approximately 20 mg) was placed in a sample holder, consisting of a thin nylon washer fastened to the top of a flat steel disc. Electrical insulating tape was placed over the explosive opening to confine the sample and to prevent the explosive powder from being blown away by the gaseous discharge. The sample holder was then placed on the base electrode with the powder directly under the needle. The spring-loaded approaching electrode (needle) was then cocked and the power supply was turned on. When the approaching electrode spring was released, the charged needle rapidly moved downward to the preset gap distance. The needle punctured the tape, penetrated the explosive powder, and discharged through the interstices of the explosive powder to the base electrode. Initiation or noninitiation of the explosive was observed. The pass criterion for this test is that there should be no reaction in 20 consecutive trials at the 0.25 joule energy level (0.02 microfarad capacitor charged to 5000 VDC) (ref 1).

Thermal Stability

The aged Comp B was subjected to several different thermal tests to determine its relative safety for self-heating under various conditions and to compare its thermal stability to Comp B from a recent lot.

Explosion Temperature

The explosion temperature test was conducted by immersing a copper blasting cap shell containing approximately 40 mg of sample in a confined state to a fixed depth in a molten metal bath at fixed temperature. Time-to-explosion was determined by measuring the time required for the blasting cap to rupture. The procedure was similar to that developed by Henkin and McGill (ref 4) and further modified by Zinn and Rogers (ref 5). The relationship between the time-to-explosion and the temperature is expressed by equation 1.

$$t = Ae^{-E_a/RT} \tag{1}$$

where
t = time (sec)
E_a = apparent activation energy (cal g-mole^{-1})
A = constant (dependent on geometry of experiment and composition of the sample)
T = explosion temperature (K)
R = universal gas constant (1.987 cal K^{-1} g-mole^{-1})

E_a is only an apparent activation energy since the entire sample is not subjected concurrently to isothermal heating.

The data was utilized in a computer program to determine the apparent activation energy and the temperature values for the 1-second and the 5-second

time-to-explosion. The temperature at 5 seconds is the value usually reported in the literature.

Differential Thermal Analysis (DTA)

Differential thermal analysis was conducted as a function of temperature by means of a Deltatherm III thermoanalyzer with a DTA accessory. The samples, approximately 1 mg, were heated in unconfined aluminum containers in a nitrogen medium at a heating rate of 10°C/min from ambient temperature through decomposition.

Thermogravimetric Analysis (TGA)

Thermogravimetric analysis (weight change measurement) was conducted using the Deltatherm III thermoanalyzer with a TGA accessory. Approximately 5 mg samples were heated in unconfined aluminum containers at a heating rate of 5°C/min in a static air medium.

Autoignition Temperature

The autoignition temperature was determined by a method using DTA (ref 6). This technique utilizes several heating rates and their respective onset and peak exotherm temperatures to solve the Kissinger's equation (ref 7). The equation is only for a first order decomposition reaction.

$$k = \frac{E_a \phi}{RT^2} = Ae^{-E_a/RT} \tag{2}$$

where
E_a = apparent activation energy (cal g-mole^{-1})
k = reaction rate (min^{-1})
A = frequency factor (min^{-1})
R = universal gas constant (1.987 cal K^{-1} g-mole^{-1})
T = peak exotherm temperature (at autoignition temperature) (K)
ϕ = heating rate (K min^{-1})

A computer program was used to calculate the autoignition temperature by extrapolating the DTA data to a near zero heating rate and assuming a rate constant of 0.05 min^{-1}. The DTA data was obtained using a Deltatherm III thermoanalyzer. The samples were heated unconfined in aluminum cups in a nitrogen atmosphere at five heating rates, from 1.3 to 20 degrees per minute.

Shelf-Life

The stability of an energetic material at a specific temperature can be estimated by a technique using DTA if the material undergoes a first order decomposition reaction. Decomposition reactions which depend on simple bond breaking are usually first order reaction and can be expressed by equation 3.

$$\frac{-dC_A}{dt} = kC_A \tag{3}$$

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where   k = specific reaction rate (min^{-1})
        C_A = concentration of reactant
        t = time (min)

Rearrangement of equation 3 and letting (a) be the initial concentration and (x) the decrease in concentration at time t, results in equation 4.

$$\frac{dx}{dt} = k(a - x) \tag{4}$$

Integrating, the first order kinetic reaction can be expressed by equation 5.

$$k = \frac{1}{t} \ln \frac{a}{a-x} \tag{5}$$

The half-life for first order reactions is independent of its initial concentration (ref 8). When one-half of the reactant has undergone decomposition, a-x = a/2, and the time, $t_{1/2}$, necessary for this to occur follows from equation 5 as

$$t_{1/2} = \frac{1}{k} \ln \left(\frac{a}{a/2}\right) = \frac{\ln 2}{k} = \frac{0.693}{k} \tag{6}$$

The specific reaction rate, k, can be calculated by means of the Arrhenius rate equation 7.

$$k = Ae^{-E_a/RT} \tag{7}$$

where   k = specific reaction rate (min^{-1})
        A = frequency factor (min^{-1})
        E_a = apparent activation energy $(cal\ g-mole^{-1})$
        R = universal gas constant $(1.987\ cal\ K^{-1}\ g-mole^{-1}$
        T = absolute temperature (K)

The frequency factor and the activation energy values are obtained from equation 2 (see section entitled "Autoignition Temperature").

Shock Sensitivity

The standardized large-scale gap test (LSGT) (ref 2) was used to evaluate the response of Comp B to an explosive shock pressure. In this test, the test explosive, called the acceptor, was cast into schedule 80 steel pipes, 4.83 cm (1.9 in.) OD by 3.81 cm (1.5 in.) ID by 14 cm (5.5 in.) long. A standard donor explosive produced a shock pressure of uniform magnitude which was transmitted to the test explosive through an attenuating inert barrier (gap). The donor consisted of two pentolite (50/50 pentaerythritol tetranitrate (PETN)/TNT) pellets, each 5.03 cm (2.0 in.) in diameter by 2.54 cm (1.0 in.) thick and was initiated with an electric detonator. The shock strength was varied by varying the thickness of the inert attenuator between the donor and the acceptor. The attenuating material consisted of two types of spacers. The first were discs of cellulose acetate (called "cards"), 5.08 cm (2.0 in.) in diameter by 0.025 cm (0.01 in.) thick. The second were cylinders of polymethyl methacrylate, 5.08 cm (2.0 in.) in diameter by 1.27 cm (0.50 in.), 2.54 cm (1.0 in.), and 5.08 cm (2.0 in.) thick. Combinations of the spacers produced any desired gap in steps of

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0.0254 cm (0.01 in.). A modified Bruceton up-and-down method was used to deter-
mine the attenuator thickness corresponding to the 50% probability of detona-
tion. The criterion for a detonation was that a clean hole had to be produced in
the 0.095 cm (3/8 in.) thick mild steel witness plate, which was placed at the
end of the steel pipe away from the point of initiation and separated from it by
spacers, 0.016 cm (0.063 in.) thick.

Physical Stability

A growth test (ref 1) was performed to determine whether or not aged Comp B
undergoes a greater irreversible dimensional change than standard Comp B when
subjected to normal temperature cycling. For this test, four cast cylindrical
samples, 1.27 cm (0.5 in.) in diameter by 1.27 cm (0.5 in.) long, were tempera-
ture cycled between -54°C (-65°F) and 60°C (140°F) for 30 cycles. A temperature
cycle consisted of raising the temperature of the conditioning chamber from -54°C
to 60°C in 40 minutes, remaining at 60°C for 35 minutes, and then lowering the
temperature back to -54°C in 165 minutes.

Detonation Velocity

The detonation velocity was measured using an ionization probe technique
with the explosive confined in thick-walled steel cylinders. Comp B from the
subject lot and a standard lot were cast into a thick-walled, hollow, steel
cylinder having an ID of 1.9 cm (3/4 in.) and walls 1.59 cm (5/8 in.) thick. The
cylinders were 15.24 cm (6 in.) long and had six holes drilled 1.9 cm (3/4 in.)
apart, perpendicular to the side and in line parallel to the axis of the cylin-
der. Ionization pins were inserted and fastened into these holes for detonation
velocity measurement. An electric detonator, inserted into the top end of the
steel cylinder, initiated the explosive. The detonation velocity was computed on
the basis of the time that was measured for the explosive shock wave front to
travel the distance between the pin wires. Time was recorded on a Biomation 8100
recorder to an accuracy of ± 10 nanoseconds.

RESULTS AND DISCUSSION

Impact Sensitivity

The impact sensitivity data for the aged Comp B is plotted in figure 1. The
full curve, the 50% and the 10% height values for the aged Comp B and Comp B from
a recent lot are presented in table 1. The results show that the impact
sensitivity of the aged Comp B is comparable to Comp B from a recent lot. The
50% impact height was 35.3 ± 1.5 cm for the aged Comp B and 34.6 ± 0.9 cm for the
explosive from the standard lot.

Friction Sensitivity

The test results are also listed in table 1. The aged Comp B crackled with the steel shoe but showed no reaction in ten trials with the fiber shoe. Samples from a standard Comp B lot showed no reaction in ten trials with either the steel or fiber shoe. Although the aged Comp B is slightly more friction sensitive than the Comp B from a recent lot, based on the test results and the pass criterion, the aged Comp B passed the friction sensitivity test.

Electrostatic Sensitivity

No reaction occurred in 20 trials at the 0.25 joule level for the aged Comp B and Comp B from a recent lot. The test results are presented in table 1. Based upon the pass criterion, the aged Comp B lot passed the electrostatic sensitivity test.

Thermal Stability

Explosion Temperature

The explosion temperature data for the aged Comp B is plotted in figure 2. The 1-second and the 5-second explosion temperatures and the apparent activation energy for the aged Comp B are compared to the values obtained for a recent lot in table 2. Similar values were obtained for the two lots. The 5-second value for the aged lot was 260°C. The recent lot had a 5-second temperature value of 259°C.

Differential Thermal Analysis (DTA)

The DTA thermogram for Comp B from the aged lot is shown in figure 3. The explosive underwent an endothermic reaction followed by an exothermic one. The extrapolated onset of the endotherm occurred at 80°C and peaked at 83°C, and was due to the melting of TNT. The exotherm began at 213°C and peaked at 239°C. The onset and peak temperatures are compared to the values obtained for Comp B from a recent lot in table 2. No significant thermal difference was observed between the two explosive lots. The two-degree temperature difference recorded for the melting of TNT is probably because the TNT in the aged Comp B contains more impurities than the TNT in the recent lot. This two-degree difference is considered to be insignificant.

Thermogravimetric Analysis (TGA)

The TGA curve for the aged Comp B is given in figure 4. The data is compared to that for standard Comp B in table 2. The table lists the temperatures at the onset of weight loss, the 10% weight loss, and the 50% weight loss. The data show no significant difference between the two lots. The 10% weight loss temperature, the value which is usually compared, occurred at 193°C for the aged Comp B and 192°C for the standard Comp B.

Autoignition Temperature

The autoignition temperature data for the aged Comp B is plotted in figure 5. The autoignition temperature, the apparent activation energy, and the frequency factor, as well as the onset and peak exotherm temperatures and the respective heating rates, are compared to the values obtained from a recent lot in table 3. The values show no significant difference between the explosives from the two lots. The apparent activation energy, frequency factor, and the autoignition temperature of the aged Comp B were 38.0 kcal/mole, 1.2×10^{16} min^{-1}, an 177°C, respectively. The values for the standard Comp B were 37.0 kcal/mole, 4.0×10^{15} min^{-1}, and 177°C.

Shelf-Life

The stability of Comp B at specific temperatures was estimated by calculating its half-life at ambient temperature, 60°C, 71°C, and the autoignition temperature. The results are listed in table 4. The calculations show that Comp B is very stable, even though the aged explosive exhibited a slight reduction in shelf-life. The half-life of Comp B is approximately 1/2 million years at ambient temperature (27°C), about 150 years at 71°C, and 161 minutes at the autoignition temperature, 177°C. Slightly lower half-life values were obtained for the aged Comp B.

Shock Sensitivity

The large-scale gap test was conducted at three different temperatures, ambient, and the two extreme temperatures of the Army operational test range, 71°C and -65°C. The test results are summarized in table 5. The 50% values for Comp B from a recent lot are also listed in the table. Similar sensitivity values were obtained for both explosives at all three temperatures. At ambient temperature, the attenuator thickness corresponding to the 50% probability of detonation was 2.16 inches for the aged Comp B and 2.26 inches for the Comp B from a recent lot. The average 50% value reported in the literature for Comp B is 2.20 inches. In general, the thicker the attenuator, the more shock sensitive is the explosive.

Physical Stability

The growth characteristics of aged Comp B and Comp B from a recent lot are compared in table 6. Both explosives had an irreversible volume change which was greater than the allowable 1.0% maximum permissible volume change cited in reference 1. Aged Comp B, however, had a slightly greater volume change than the explosive from the recent lot, 2.44% to 1.52%.

Detonation Velocity

The detonation velocity measurements were conducted in duplicate at three different temperatures, ambient, 71°C, and -54°C. The results, summarized in table 7, show no significant difference between the detonation velocities of the

two explosives. At ambient temperature, a detonation velocity of 7,780 m/sec was obtained for the aged Comp B. The average density was 1.679 g/cm^3. The detonation velocity of Comp B from a recent lot at a density of 1.688 g/cm^3 was 7,880 m/sec. The detonation velocities of the two explosives at -54°C were 7,905 m/sec and 7,740 m/sec, respectively. At 71°C, the detonation velocities were 7,680 m/sec and 7,670 m/sec. The detonation velocities reported in the literature for unconfined 1-inch diameter Comp B charges having a density of 1.68 g/cm^3 are 7,840 m/sec at ambient temperature and 7,720 m/sec at -54°C.

CONCLUSIONS

1. The Comp B from the aged lot, HOL 4-330, satisfied the electrostatic sensitivity and the friction sensitivity pass criteria for the qualification of explosives for military use (ref 1). The explosive, however, was slightly more friction sensitive than standard Comp B. It crackled with the steel shoe, while no reaction was obtained with standard Comp B.

2. The explosive temperature and the autoignition temperature values showed no significant difference between the explosives from the aged lot and a recent lot.

3. The DTA/TGA temperature measurements, which are indicative of decomposition, disclosed no signficant thermal difference between Comp B from the aged lot and a standard lot. The shelf-life (half-life) calculation showed that Comp B is very stable.

4. The LSGT showed that the aged Comp B has the same shock sensitivity as standard Comp B.

5. The irreversible growth values for the explosives from both lots were greater than the allowable 1.0% maximum permissible volume change cited in reference 1. Aged Comp B exhibited a slightly greater irreversible volume change than the explosive from a recent lot.

6. The detonation velocity measurements showed no perceptible difference in the detonation velocity values obtained from the aged lot and a recent lot.

7. Based on all of the test data, it can be concluded that no significant changes have occurred to the Comp B in Lot HOL 4-330, since it was manufactured in June 1952. The explosive can be used for commercial or military uses, if the slightly greater irreversible volume change can be tolerated.

RECOMMENDATION

It is recommended that Comp B from Lot HOL 4-330 be used if the slightly greater irreversible volume change can be tolerated. The irreversible problem can be lessened by mixing new Comp B with the aged Comp B. Further testing may be required in the actual end item configuration to determine if the greater

irreversible volume change is detrimental. To assure that there is no anomaly between small scale laboratory testing and a large scale loaded projectile, additional functional tests may also be required. These tests could include a cylinder test, a fragmentation test, a jet penetration test, and an activator and/or a setback test.

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Table 1. Impact, friction, and electrostatic sensitivity test results

Test	Aged Comp B (Lot HOL 4-330)					Standard Comp B (Lot HOL 053-97)				
Impact sensitivity (ERL, Type 12)										
50% firing height (cm)	35.3 ± 1.5					34.6 ± 0.9				
10% firing height (cm)	20					18				
full firing curve (20 trials per ht)										
height (cm)	40	35	30	25	20	45	40	35	30	25
% fired	90	55	55	45	15	80	80	70	65	40
Friction sensitivity (ARDC large-scale pendulum)										
steel shoe (10 trials)	crackles					no reaction				
fiber shoe (10 trials)	no reaction					no reaction				
Electrostatic sensitivity (approaching electrode)										
0.25 joule (20 trials)	no reaction					no reaction				

Table 2. Thermal stability results

Test	Aged Comp B (Lot HOL 4-330)	Standard Comp B (Lot HOL 053-97)
Explosion temperature		
1-sec (°C)	335	339
5-sec (°C)	260	259
Apparent activation energy (kcal/mole)	13.9	13.2
DTA (Deltatherm III thermoanalyzer, 10°C/min in a nitrogen medium)		
Endotherm		
extrapolated onset (°C)	80	82
peak (°C)	83	85
Exotherm		
extrapolated onset (°C)	213	214
peak (°C)	239	239
TGA (weight loss) (Deltatherm III thermoanalyzer, 5°C/min in a static air medium)		
extrapolated onset (°C)	157	146
10% (°C)	193	192
50% (°C)	226	226

Table 3. Calculation of activation energy, frequency factor, and autoignition temperature

Heating rate (°C/min)	Aged Comp B (Lot HOL 4-330)		Standard Comp B (Lot HOL 053-97)	
	Onset temperature (°C)	Peak temperature (°C)	Onset temperature (°C)	Peak temperature (°C)
1.3	183.0	212.0	184.0	215.0
2.6	192.5	223.0	195.5	221.5
5.2	205.0	230.5	203.0	230.0
10.5	213.0	239.0	214.0	239.0
21.0	218.0	249.0	220.0	250.0
Autoignition temperature (°C)	177		177	
Apparent activation energy (Kcal/mole)	38.0		37.0	
Frequency factor (min^{-1})	1.2×10^{16}		4.0×10^{15}	

Table 4. Calculation of shelf-life (half-life)

Temperature (°C)	Aged Comp B (Lot HOL 4-330) Half-life (yrs)	Standard Comp B (Lot HOL 053-97) Half-life (yrs)
27 (ambient)	2.9×10^5	5.2×10^5
60	630	950
71	125	150
	minutes	minutes
177 (autoignition)	161	161

Table 5. Large-scale gap test results

Explosive	Density (g/cm³)	50% Point (in.)
Aged Comp B (Lot HOL 4-330)		
Ambient temperature	1.68	2.16
71°C		1.97
-65°C		2.02
Standard Comp B (Lot HOL 79E-100-696)		
Ambient temperature	1.69	2.26
71°C		2.23
-65°C		2.01
Literature value (average)		
Ambient temperature	1.68-1.69	2.20

Table 6. Irreversible growth of Composition B

1.27 cm diameter by 1.27 cm long, cast cylinders

Explosive	Initial density (g/cm^3)	Diameter change (%)	Length change (%)	Weight change (%)	Density change (%)	Volume change (%)
Aged Comp B (Lot HOL 4-330)	1.684	0.80	0.84	-0.31	-2.73	2.44
Standard Comp B (Lot HOL 053-425)	1.694	0.36	0.46	-0.08	-1.59	1.52

NOTE: Temperature cycled between -54°C and 60°C for 30 cycles.

Table 7. Detonation velocity test results

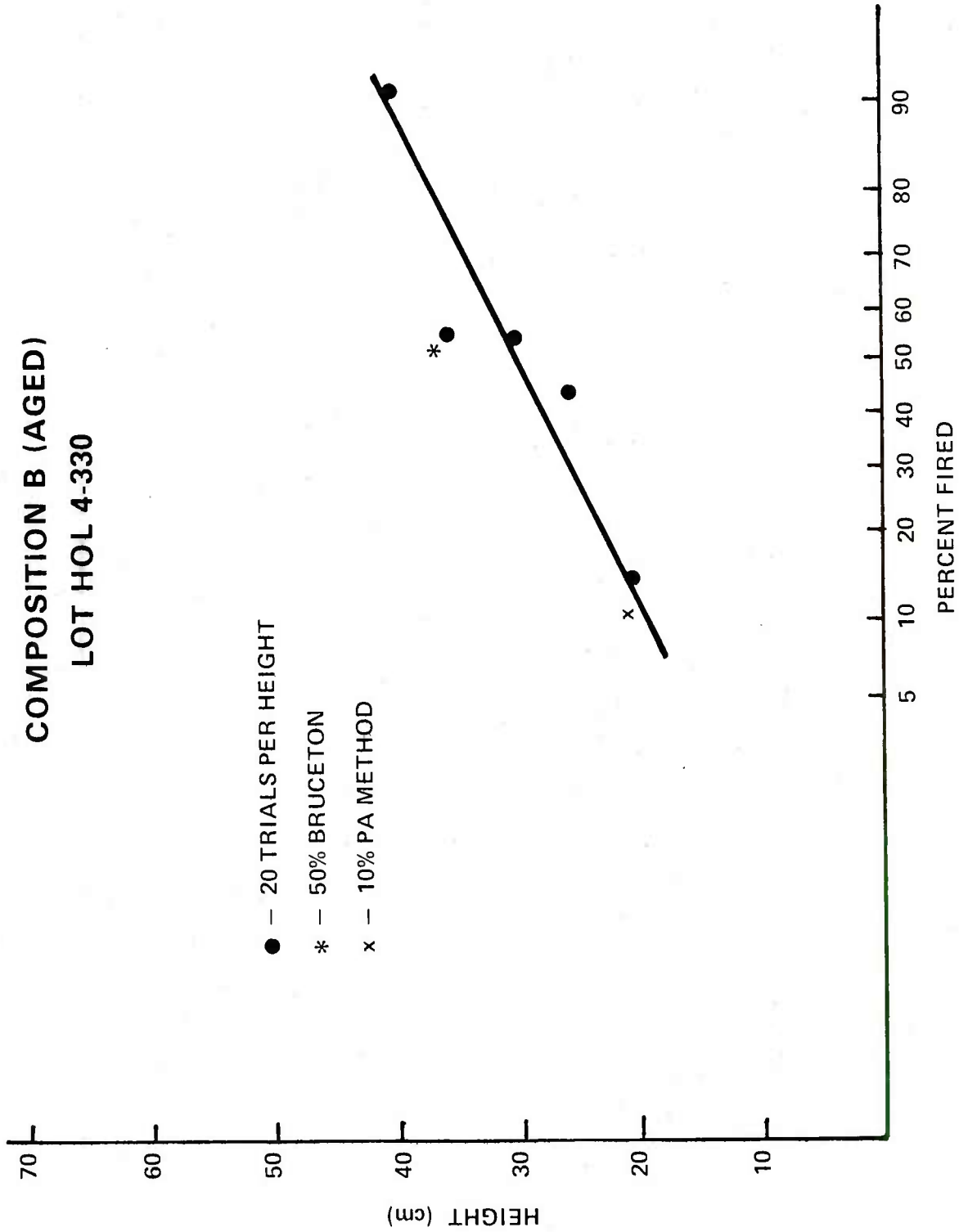| Explosive	Density (g/cm^3)	Detonation velocity (mm/μsec)
Aged Comp B (Lot HOL 4-330)		
Ambient temperature	1.679	7.780
71°C		7.680
-54°C		7.905
Standard Comp B (Lot HOL 79E-100-696)		
Ambient temperature	1.688	7.880
71°C		7.670
-54°C		7.740
Literature value (unconfined, 1-in. diameter)		
Ambient temperature	1.68	7.840
-54°C		7.720

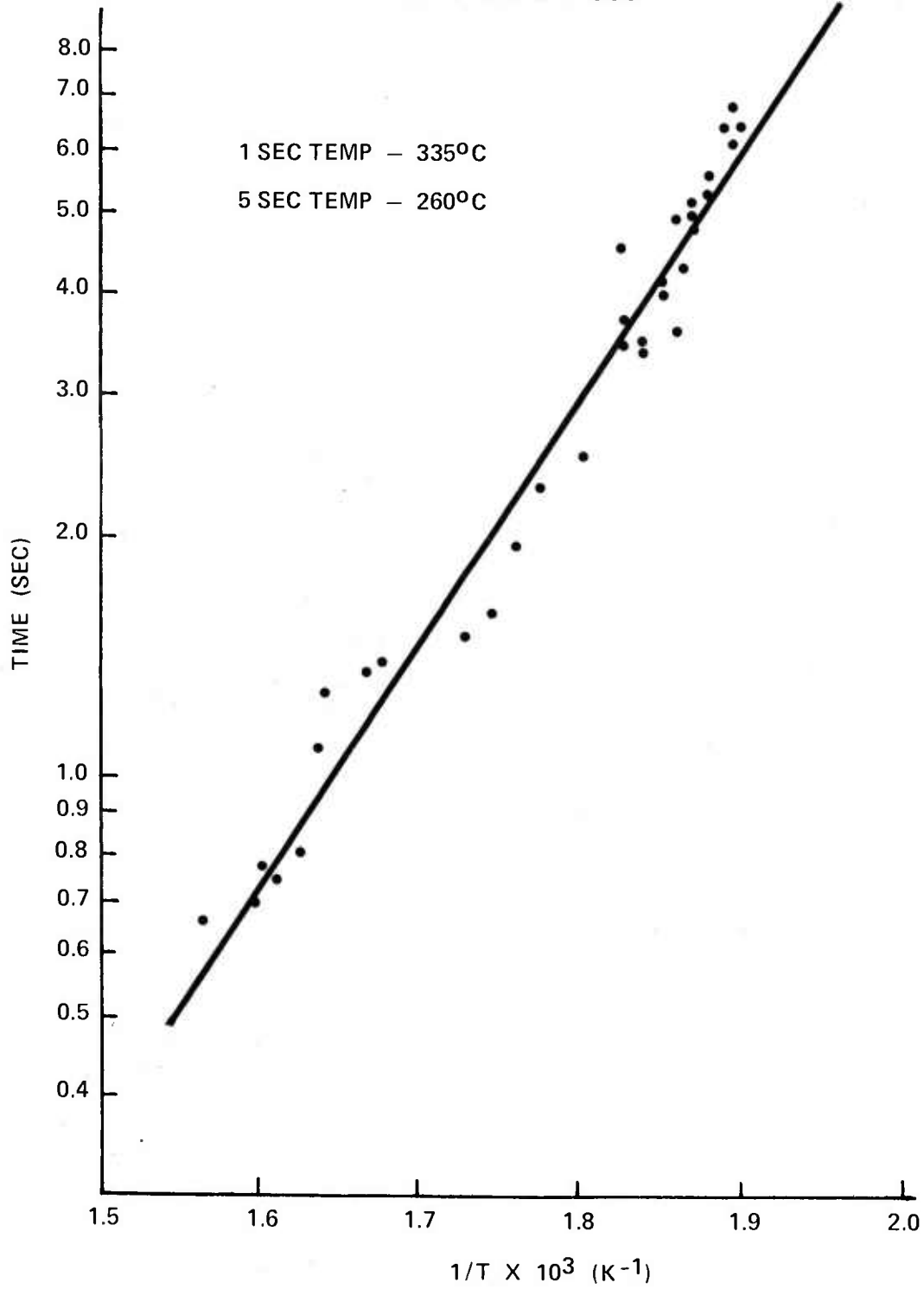Figure 1. Impact sensitivity curve for Composition B, Lot HOL 4-330

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Figure 2. Explosion temperature curve for Composition B, Lot HOL 4-330

COMPOSITION B (AGED)
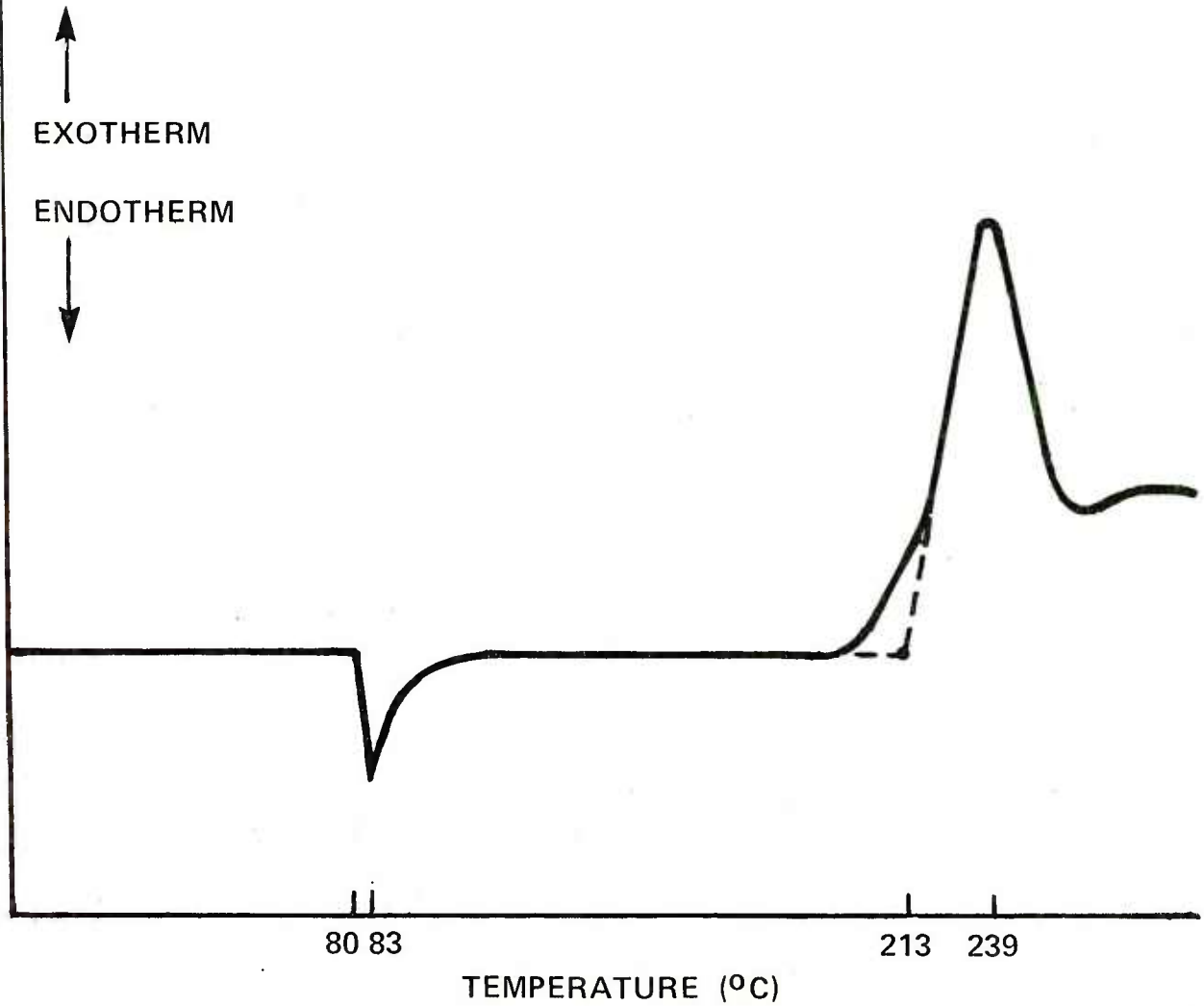## LOT HOL 4-330

WEIGHT = 1.0 mg

RATE = 10°C/MIN

EXOTHERM

ENDOTHERM

80 83

213 239

TEMPERATURE (°C)

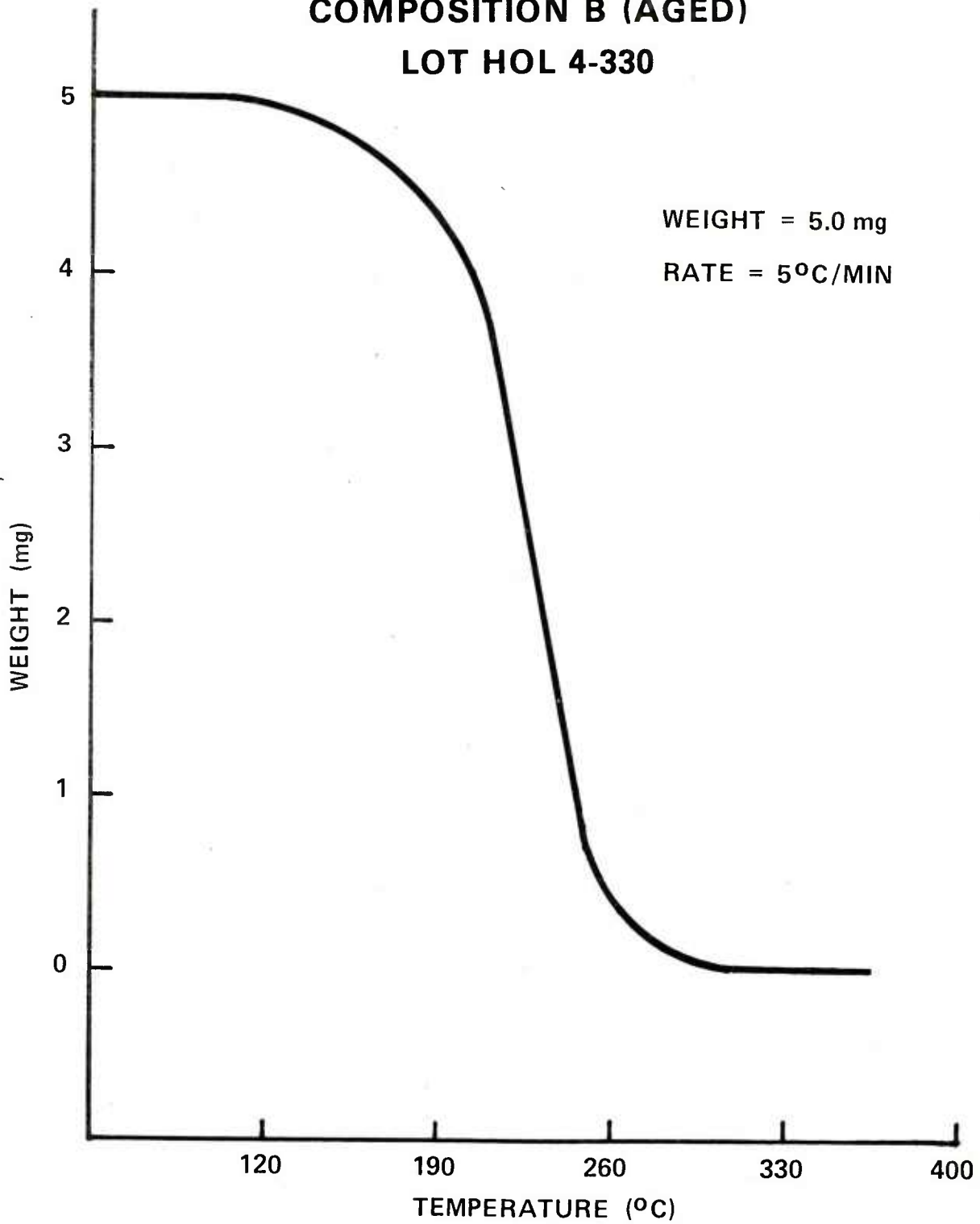Figure 3.   DTA thermogram of Composition B, Lot HOL 4-330

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Figure 4. TGA thermogram of Composition B, Lot HOL 4-330
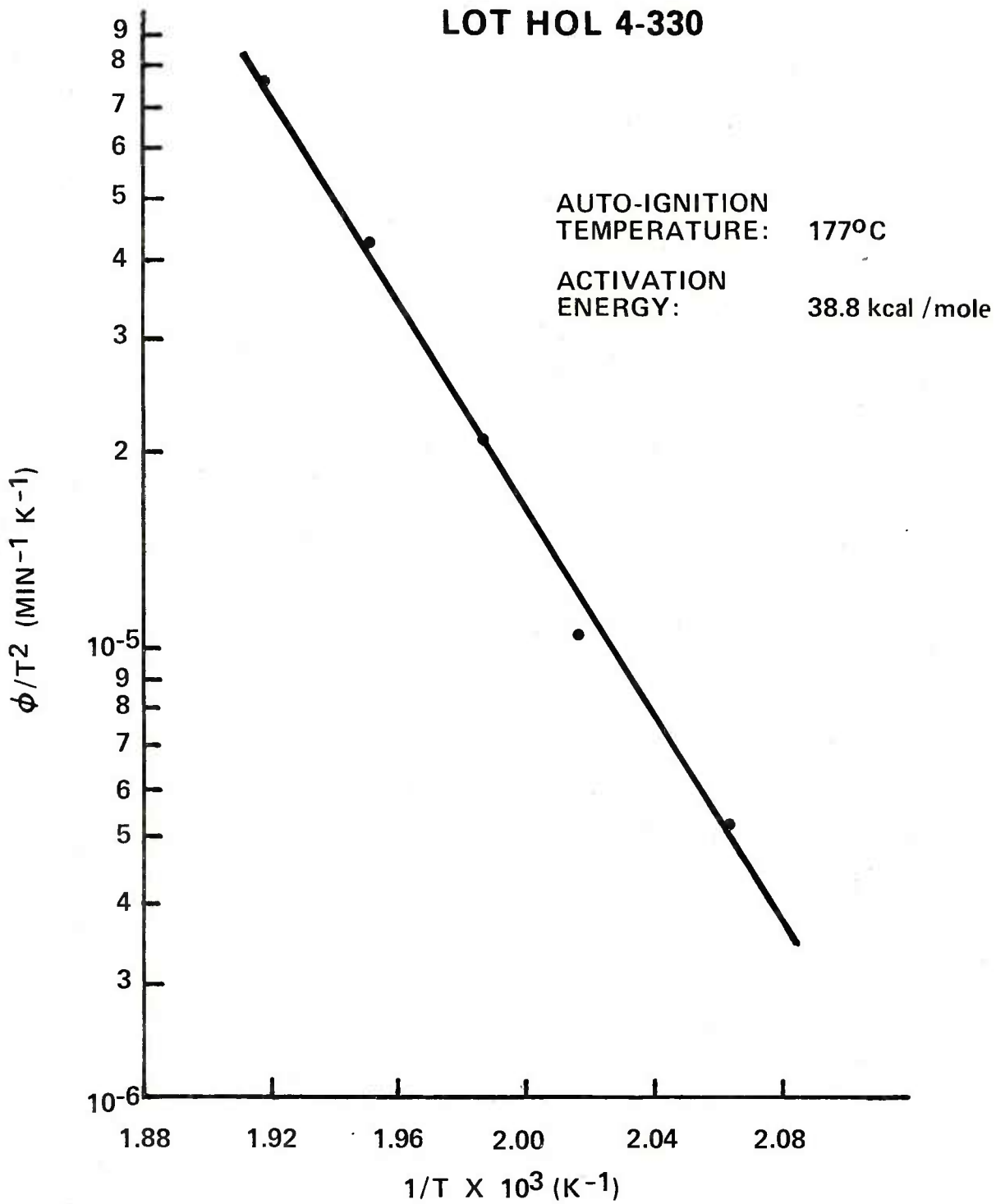
COMPOSITION B (AGED)

LOT HOL 4-330

Figure 5. Autoignition temperature curve for Composition B, Lot HOL 4-330

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