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Corner-Turning Characteristics of TATB/HMX/Kel-F Mixtures

MASTER

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JANUARY 1983

Process Development
Endeavor No. 101

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ABSTRACT

A factorial experiment was conducted to determine the effects of HMX content, HMX particle size and TATB particle size in TATB/HMX/Kel-F formulations containing 5% by weight Kel-F 800 binder on corner turning performance at ambient and -54 C. TATB and HMX particle size variations did not significantly affect differences in corner turning performance between the two temperatures. With increasing HMX contents the effect of temperature on corner turning became less and at the maximum HMX content studied, 25%, the corner turning levels were almost equal at ambient and -54 C.

DISCUSSION

A study was conducted to evaluate corner turning characteristics at ambient and -54 C of TATB/HMX/Kel-F 800 formulations containing 5% by weight Kel-F and HMX contents of 5 to 25% by weight. The final objective of the project is the development of a TATB/HMX/Kel-F 800 composition with similiar corner turning characteristics at ambient and -54 C. The effects of TATB and HMX particle sizes and HMX content were investigated in the study.

Ten compositions were formulated in a 30-litre reactor. A standard slurry process for binary explosives was used. Dried HMX and TATB were slurried in water and a lacquer consisting of Kel-F 800 dissolved in methyl isobutyl ketone and n-butyl acetate was added to the slurry. The mixture was stirred at a low agitation rate, additional water introduced, and the solvents evaporated by heating the slurry and passing air/nitrogen over the surface of the mixture. After firm granules formed, the slurry was cooled and the mixture removed from the reactor. Excess water was separated by decantation and the granules were dried at 121 C for 16 hours.

Table I contains the nominal compositions of the ten lots investigated. The actual compositions as determined by analysis are given in Table II. The particle size distributions for the coarse and fine HMX and TATB powders are plotted in Figs. 1 - 4. Production grade lots of the two explosives were used for the coarse powders and the fine particle size distributions were obtained from micronization. The medium particle size distributions were formed by blending equal weight percentages of the coarse and fine particle size powders.

Impact sensitivities and thermal stabilities of the lots are given in Table III. A typical DSC thermogram (Fig. 5) depicts HMX decomposition near 280 C and TATB decomposition near 370 C. DSC shows no indication of an interaction between HMX and TATB. The quantity of gas produced in the chemical reactivity test is consistent with that generated for each of the individual explosives, i.e., PBX 9502 and LX-10. Impact sensitivity of the compositions shows a weak relationship to the HMX content. The compositions with 25% HMX are generally more sensitive than the others.

Test specimens for the corner turning test were pressed-to-shape to the same percent theoretical maximum density, 97.87% with a σ of 0.09, in order to eliminate density as a variable in the test.

Data shown in Table IV are from 16 tests randomly fired using a modified version of the LANL corner turning test. The acceptor is a pressed-to-shape 50.8 mm diameter 50.8 mm long pellet. The initiation assembly for these tests consists of a 12.7 mm diameter by 12.7 mm long PBX 9407 pellet (nominal density 1.62 g/cc) and an SE-1 detonator. The three components are centered within 0.1 mm. Magnesium oxide is used for light enhancement. Two sides of the acceptor pellet are observed through PMMA prisms, while the bottom is viewed directly by a B&W Mod. 770 streak camera. Nominal film magnification is 0.2 and the writing rate is 12 km/s.

Corner turning distances (CTD) shown in both tables are determined by measuring the distance from the initiator end of the acceptor to the first breakout. The two distances are divided by the magnifications available (usually three), normally providing six CTD's for each test. These values provide the average CTD and a standard deviation as shown in the tables. Expected repeatability of CTD measurements (determined from other experiments) is about ± 1 mm.

Table V shows data from six tests using replicate formulations. They are presented separately because they do not represent true statistical center points for the particle size variables (HMX and TATB). The "medium" particle sizes were approximated by blending the coarse and fine materials used in the factorial experiments. Analyzing the data for curvature in the factorial experiments might be misleading.

Since two initiation failures occurred during the factorial experiment, factorial analysis was impossible. However, stepwise and multiple linear regression analyses indicated that only %TATB and temperature were significant variables. Fig. 6 shows that similar corner turning performance is obtained at -54 C and 21 C by using 70% TATB, 25% HMX and 5% Kel-F. TATB and HMX particle sizes have no statistically significant effects on corner turning performance at these two temperatures with this composition.

CONCLUSIONS

Although some temperature effect is apparent for the 80% TATB formulation, it is not a statistically strong effect, suggesting that more exploration should be done near the 80% TATB point to obtain a formulation possessing similar corner turning performance at -54 C and 21 C and as high a TATB content as possible.

Table I. Nominal Compositions and Particle Sizes

	HMX		TATB		Kel-F 800
Batch No.	Content (% by Weight)	Particle Size	Content (% by Weight)	Particle Size	Binder % by Weight
1336-185A-01	5	coarse[a]	90	coarse[b]	5
2035-185C-01	5	fine[c]	90	coarse	5
2068-185D-01	5	coarse	90	fine[d]	5
2076-185E-01	5	fine	90	fine	5
2034-185B-01	25	coarse	70	coarse	5
2034-185F-01	25	fine	70	coarse	5
2068-185G-01	25	coarse	70	fine	5
2077-185H-01	25	fine	70	fine	5
2096-185J-01	15	medium[e]	80	medium[f]	5
2103-185J-01	15	medium	80	medium	5

[a]Grade II Class A HMX Lot 920-27

[b]Production Grade TATB Lot 80L000E065

[c]Micronized HMX Lot 2018-106M-01

[d]Micronized TATB Lot 2077-135M-01

[e]50% Grade II, Class A HMX/50% Micronized HMX

[f]50% Production TATB/50 Micronized TATB

Table II. Compositional Analysis and Densities

Material Lot Nos.*	Nominal Composition % TATB	Nominal Composition % HMX	Nominal Composition % Kel-F 800	Actual Composition Weight % TATB	Actual Composition Weight % HMX	Actual Composition Weight % Kel-F 800	Nominal TMD (Mg/m^3)	Actual TMD (Mg/m^3)
1336-185A-01	90	5	5	90.71 ± 0.34	4.99 ± 0.15	4.38 ± 0.12	1.9403	1.9398
2035-185C-01	90	5	5	90.38 ± 0.13	4.72 ± 0.13	4.89 ± 0.07	1.9403	1.9403
2068-185D-01	90	5	5	89.51 ± 0.14	5.19 ± 0.04	5.18 ± 0.08	1.9403	1.9403
2076-185E-01	90	5	5	90.86 ± 0.08	4.92 ± 0.03	4.40 ± 0.16	1.9403	1.9398
2034-185B-01	70	25	5	70.28 ± 7.90	25.20 ± 0.61	4.82 ± 0.54	1.9336	1.9333
2034-185F-01	70	25	5	72.31 ± 0.25	23.03 ± 0.43	5.22 ± 0.26	1.9336	1.9344
2068-185G-01	70	25	5	69.50 ± 0.35	25.27 ± 0.18	4.46 ± 0.25	1.9336	1.9331
2077-185H-01	70	25	5	71.26 ± 0.28	25.22 ± 0.14	4.29 ± 0.08	1.9336	1.9329
2096-185J-01	80	15	5	80.88 ± 0.40	14.74 ± 0.34	4.26 ± 0.10	1.9369	1.9364
2103-185J-01	80	15	5	80.80 ± 0.10	14.89 ± 0.30	4.11 ± 0.10	1.9369	1.9362

*For detailed breakdown of lot numbers of raw explosive and particle size, see Table I.

Table III. Impact Sensitivity and Thermal Stability

	Nominal Composition[a]			Particle Size[b]		Drop Hammer		DSC Exotherms		Chemical Reactivity Test[c]						
Lot No.	% TATB	% HMX	% Kel-F	TATB	HMX	H_{50},cm 12A	H_{50},cm 12B	1st Peak	2nd Peak	N_2	O_2	CO	NO	CO_2	N_2O	Total
1336-185A-01	90	5	5	coarse	coarse	>200[c]	>200[c]	278.6	375.5	0.013	0.001	-	-	0.005	0.001	0.020
2035-185C-01	90	5	5	coarse	fine	>200	>200	279.0	373.6	0.009	-	-	-	0.003	0.001	0.013
2068-185D-01	90	5	5	fine	coarse	>200	180	278.3	372.2	0.005	-	-	-	0.003	-	0.008
2076-185E-01	90	5	5	fine	fine	>200	>200	277.5	373.6	0.005	-	-	-	0.004	0.001	0.010
2034-185B-01	70	25	5	coarse	coarse	95	114	278.7	374.0	0.011	0.001	-	-	0.003	0.001	0.016
2034-185F-01	70	25	5	coarse	fine	~200	160	279.7	372.7	0.011	0.001	-	-	0.003	T	0.015
2068-185G-01	70	25	5	fine	coarse	129	160	279.0	371.8	0.018	0.002	T	-	0.006	0.001	0.027
2077-185H-01	70	25	5	fine	fine	200[d]	101	278.9	371.1	0.010	0.001	-	-	0.002	0.001	0.014
2096-185J-01	80	15	5	medium	medium	>200	>200	279.4	372.6	-	-	-	-	-	-	-
2103-185J-01	80	15	5	medium	medium	>200	180	279.4	372.9	-	-	-	-	-	-	-

[a]For actual compositions, see Table II

[b]For explanation of terms, see Table I

[c]No reactions were observed at the maximum height, 200 cm

[d]A few no-reactions at 200 cm but too much scatter to determine H_{50}

[e]Values are in mℓ corrected to STP of 0.250 g after 22 hours at 120 C

Table IV. Factorial Experiment

% HMX	TATB π[a]	HMX π[b]	Corner Turning Distance (mm) ± σ (mm) at Temperature 21 C	-54 C
5	C	C	16.5 ± 1.0	25.3 ± 0.2
5	C	F	12.7 ± 0.3	28.9 ± 1.6
5	F	C	13.9 ± 1.0	Failed
5	F	F	13.6 ± 2.1	Failed
25	C	C	4.9 ± 0.5	4.9 ± 0.2
25	C	F	4.7 ± 0.6	3.7 ± 0.5
25	F	C	3.2 ± 1.5	3.5 ± 0.7
25	F	F	1.6 ± 0.6	3.0 ± 1.2

[a]C - TATB Lot 80L000E065;
F - Micronized TATB Lot 2077-135M-01

[b]C - HMX Grade II Class A Lot 920-27
F - Micronized HMX Lot 2018-106M-01

Table V. Attempted Center Point Data

Formulation Identifier	Corner Turning Distance (mm) ± σ (mm) at Temperature 21 C	-16 C	-54 C
2096[a]	4.1 ± 1.0	6.2 ± 0.9	6.9 ± 0.6
2103[a]	3.9 ± 0.5	7.4 ± 0.8	6.9 ± 1.0

[a]These two formulations are nominal replicates of 80/15/5 weight percent TATB/HMX/Kel-F. The TATB is a 50/50 blend of TATB, Lot 80L000E065 and micronized TATB Lot 2077-135M-01. The HMX is a 50/50 blend of Class A HMX Lot 920-27 and Micronized HMX Lot 2018-106M-01.

TATB Lot 80L000E065

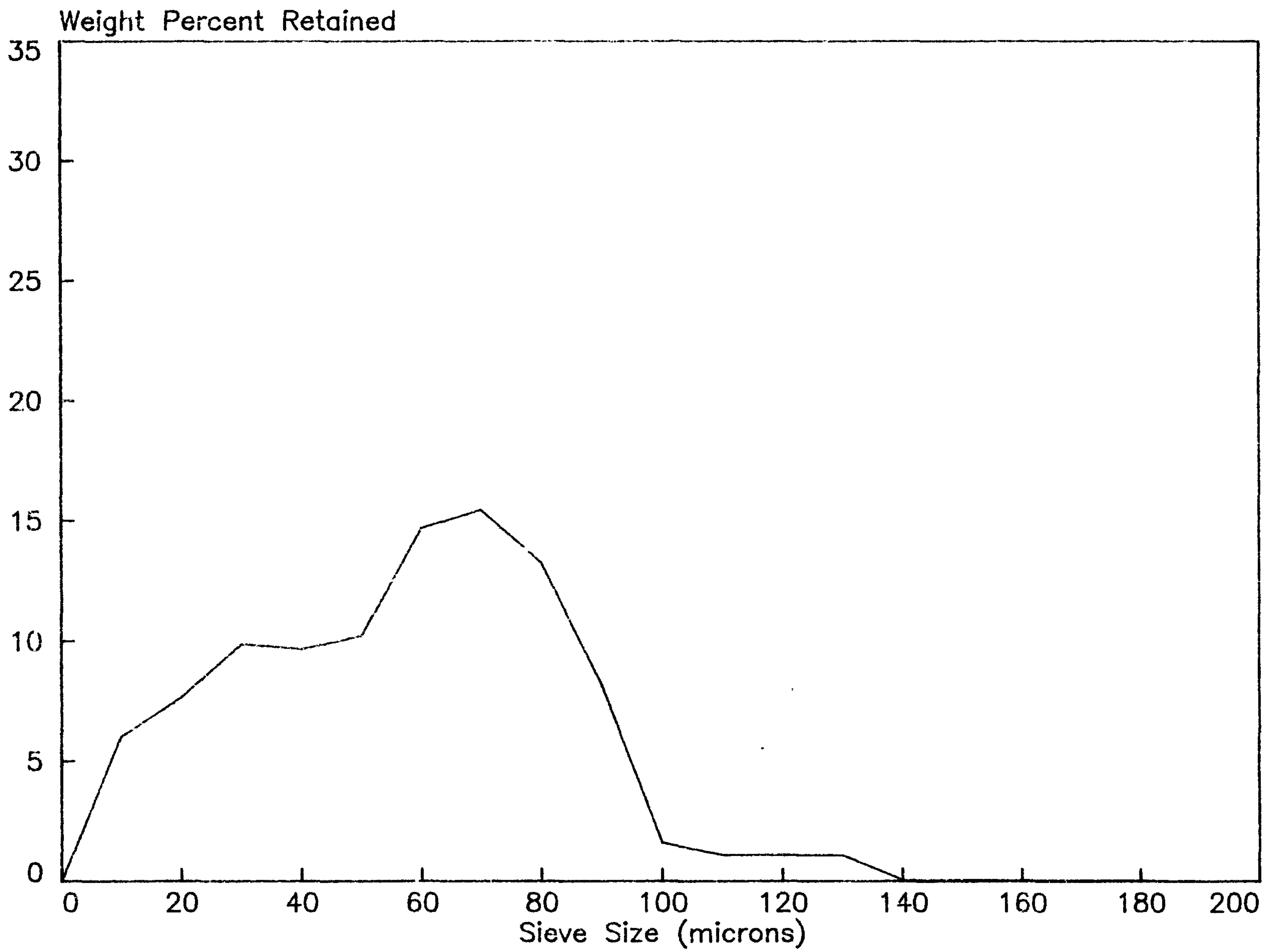

Fig. 1. Coarse TATB Sieve Analysis Before Formulation

Micronized TATB 2077-135M-01

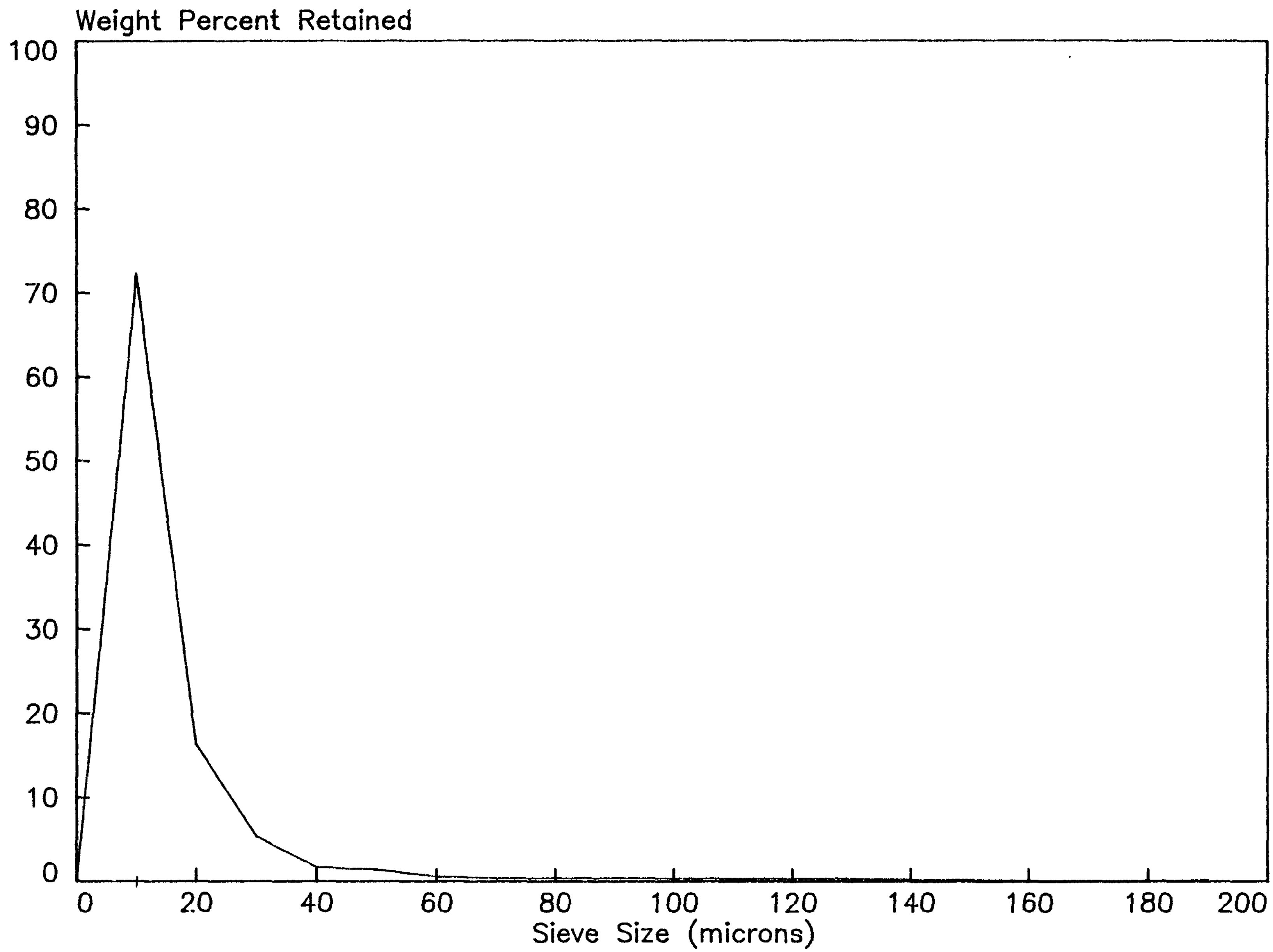

Fig. 2. Fine TATB Sieve Analysis Before Formulation

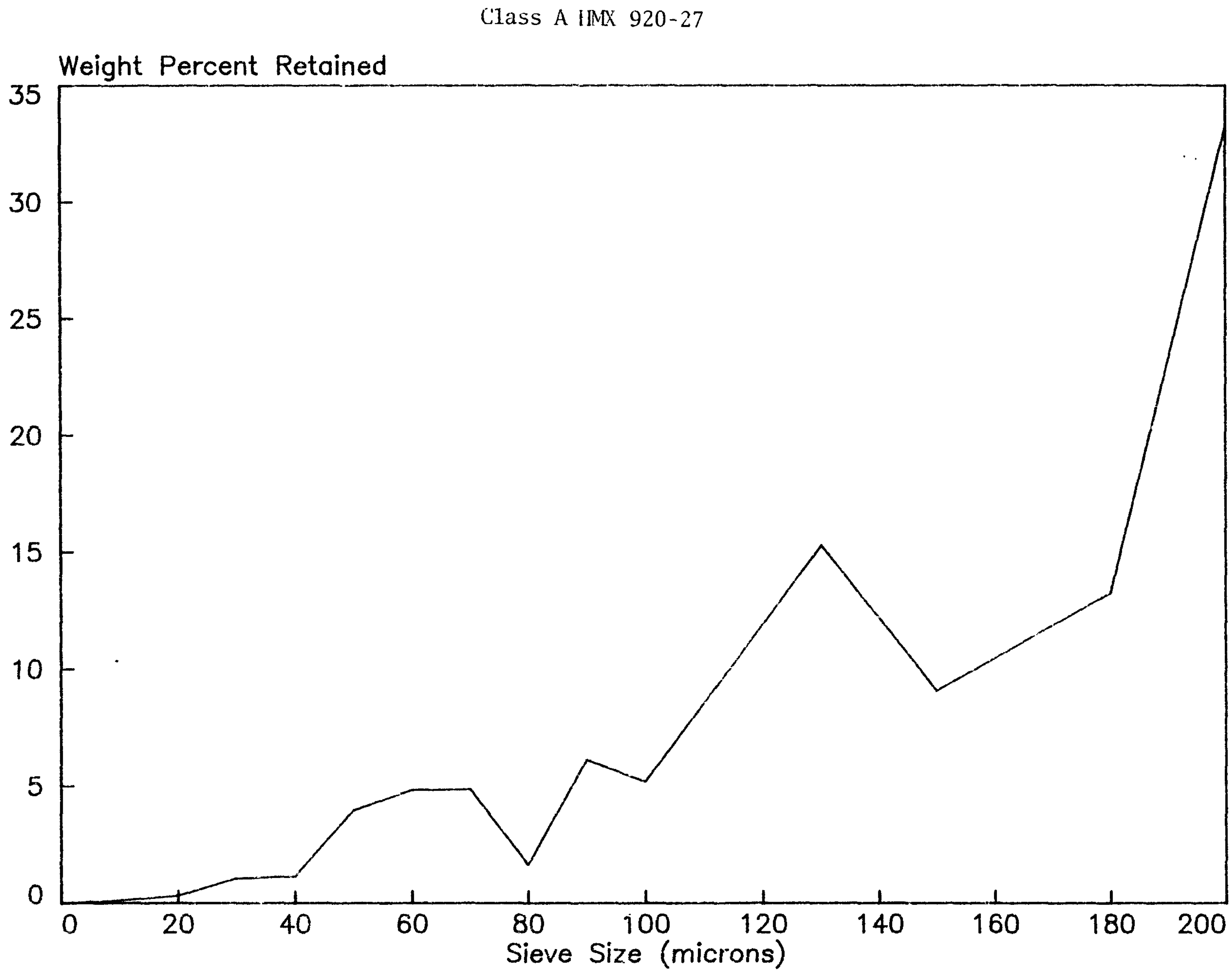

Fig. 3. Coarse HMX Sieve Analysis Before Formulation

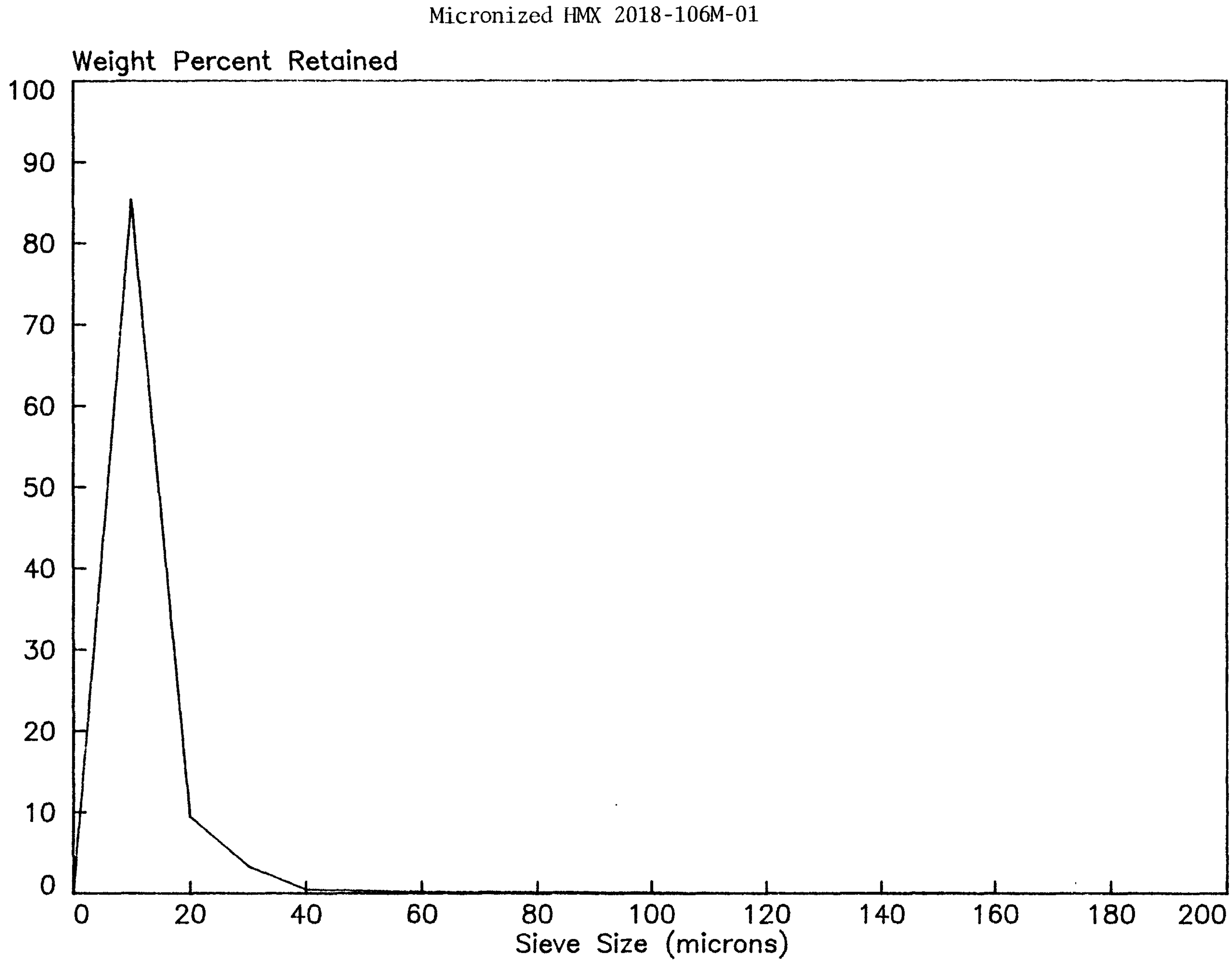

Fig. 4. Fine HMX Sieve Analysis Before Formulation

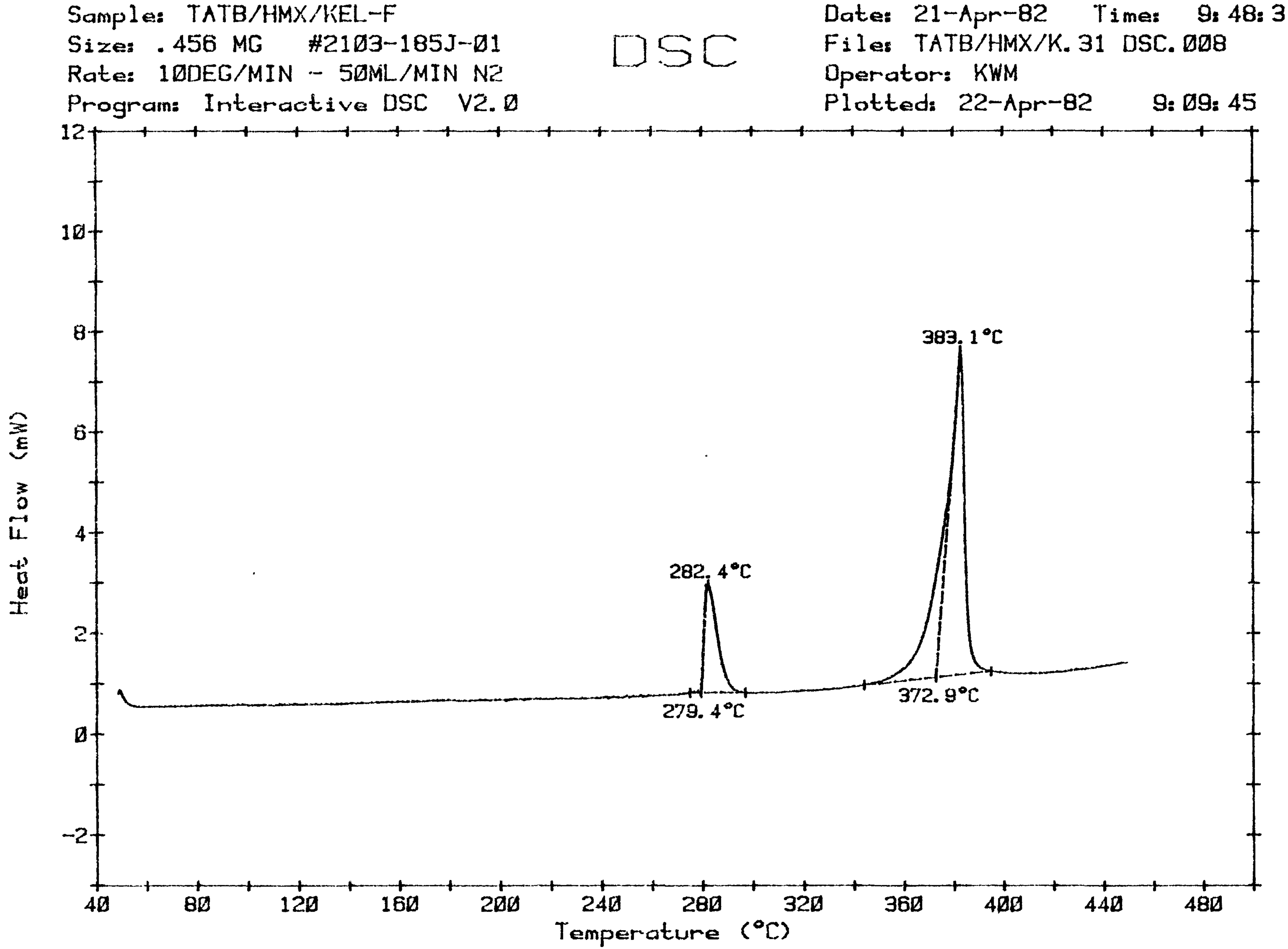

Fig. 5. Typical DSC Thermogram for 80% TATB/15% HMX/5% Kel-F Formulations

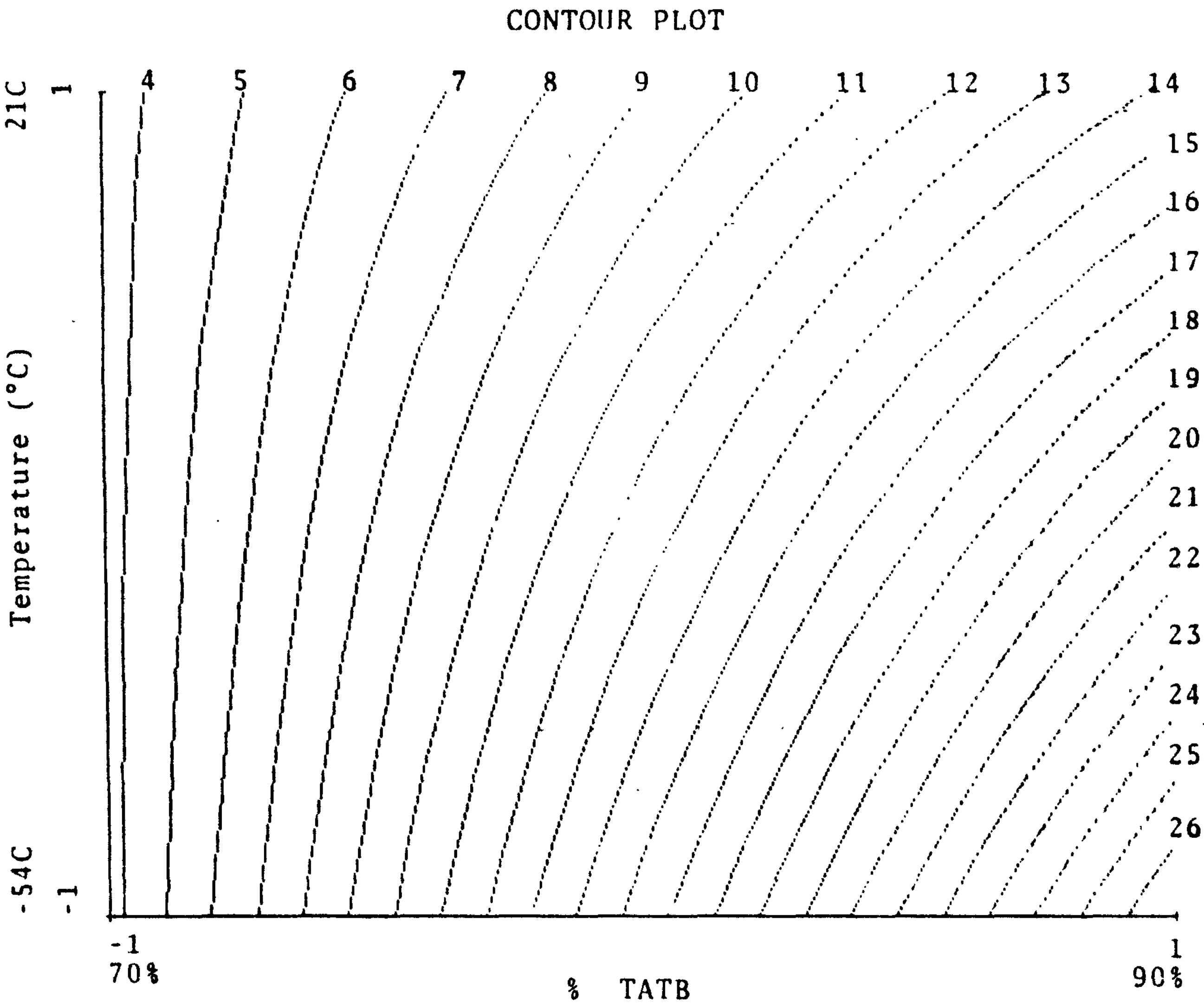

Fig. 6. Contour Plot of Corner Turning Distances

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