MHSMP-72-74

MASTER

PARTICLE SIZE ANALYSIS OF HMX

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DEVELOPMENT DIVISION

OCTOBER 27, 1972

For
Hercules Incorporated
Magna, Utah

EB

Mason & Hanger-Silas Mason Co., Inc.

operated for the
ATOMIC ENERGY COMMISSION
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INTRODUCTION

Particle size distribution (π) of three batches of Hercules-supplied HMX have been analyzed by the Pantex Development Division. π's were determined by the specified sieve analysis having a nest range of 180 through 10 μ. These sieves were used to comply with Hercules requests; they are also those customarily used for HMX qualification. Five analyses for each batch were performed on the material > 10 μ and duplicates analysis for the < 10 μ material.

On August 22, 1972 Robert Sthnettler visited our laboratory to discuss particle size analysis. He observed sieve analysis performed on the Pantex automatic sieving apparatus. Written procedures involving sieving HMX as well as a complete set of blueprints of the sieving apparatus were given to him at that time. Later, upon the request of R. Levitt, a complete set of Sepia prints of the sieving apparatus was mailed to Hercules.

The effects of ultrasonic vibration on HMX particle size are of interest to Hercules (having been discussed by telephone with Sthnettler) and a study on that is included in this report. Specific procedures used in the sieving of HMX as well as a discussion of sieve analysis and the Pantex sieving apparatus are also included.

Particle Distribution of Hercules Supplied HMX

The sieve analysis consisting of 5 runs for each of three batches of HMX has been completed by Pantex for Hercules Incorporated, Bacchus Works Plant, Magna, Utah. The analysis simulates Holston's analysis (which in turn was a consequence of our early work on small sieves). Isobutyl acetate was used as an elutant to separate HMX through a nest consisting of sieve sizes 180, 150, 130, 100 and increments of 10 μ down to 10 μ. Duplicate analysis below 10 μ was done in increments of 8, 6, 4, and 2 μ.

Batch identification were as follows:

1. 930-6 Sample 1 6H6F 62-57
2. 961-5E
3. L/N 148-61

Sieve analysis show batches 961-5E and 930-6 to be similar in distribution; each retained approximately the same amount of material on each sieve. Batch 961-5E had an arithmetic mean particle size of 11.01 μ, while batch 930-6 arithmetic mean was 16.29 μ. Batch L/N 148-61 was evenly distributed: the weight percentage retained for the various sieves were nearly equal. The major modes at 100 μ and 60 μ were ∿12% while the other sieves were ∿5%. The arithmetic mean particle size for L/N 148-61 was 69.59 μ. Distributions for each batch are shown in condensed forms in Tables I, II, and III; detailed computer printout and plots are in enclosures I, II, and III (plots for each respective batch are at the end of its appropriate enclosure).

Π's were based on the weight % retained by each sieve. Particle size was denoted as that of the sieve; calibration, by microscopy, of each sieve's average opening was within ±.5 μ.

Weight percentage retained is calculated by the weight retained divided by the total weight retained x 100. Total weight retained is used instead of starting sample weight because samples were not dried before sieving, and sample loss is not linear with respect to size. For each duplicate in enclosures I, II, and III, a combined analysis is calculated. This is done by adding the weight retained in analyses 1 and 2 for each sieve divided by combined total retained for both analyses x 100. This is done to minimize sampling error, which would be more effective than averaging the weight % retained. Tables I, II and III have combined analyses for the total retained for the 5 analyses on each sieve divided by total retained for all 5 analyses x 100. (Do not confuse an average of the weight % retained with the combined analysis. Mean weight % retained are shown in column 10 of each table.) Standard deviation in weight % retained for each sieve > 10μ were all <0.8% and average ~0.2%. For any analysis having a standard deviation <1% the procedure may be said to be very reproducible. Accuracy must be achieved by proper washing, calibration of sieves and appropriate particle shape.

$$\text{Standard deviation} = s = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \bar{X})^2}{N-1}}$$

$$\text{Variance} = s^2 = \frac{\sum_{i=1}^{N} (X_i - \bar{X})^2}{N-1}$$

Arithmetic mean for weight % retained and is not be confused with arithmetic mean particle size calculated in the detail print outs in enclosures I, II, and III because the latter is based on sieve size and not weight % retained.

$$\text{Arithmetic mean} = \bar{X} = \frac{\sum_{i=1}^{N} X_i}{N}$$

Arithmetic mean based on particle size between two sieves.

$$\bar{X}_\alpha = \sum_{i=1}^{N} \left[\frac{\left(\frac{X_1 + X_2}{2} \right) w_i}{w} \right]$$

with X_1 being upper sieve size and
X_2 bottom sieve size of two adjacent sieves
w_i weight retained between sieves X_1 and X_2
w total weight retained by sieve nest.

Geometric mean based on geometric mean particle size between two sieves.

$$\bar{X}_g = \frac{\sum_{i=1}^{N} [(\sqrt{X_i X_2})\ w_i]}{w}$$

The differences are significant, thus emphasizing the need for stating clearly how particle size average of screened material are derived.

TABLE I. HERCULES HMX 930-6 Sample 1 6H6F 62-57

Weight % Retained

Sieve Size	Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Combined Analysis	% Coarser Than Sieve Size	% Finer Than Sieve Size	Arithmetic Mean	Variance	Standard Deviation
180	.27	.57	.56	.48	.50	.42	.42	99.58	.464	0.0101	0.1005
150	.25	.58	.61	.45	.60	.45	.87	99.13	.498	0.0187	0.1367
130	.25	.53	.72	.57	.58	.46	1.33	98.67	.518	0.0233	0.1528
100	.35	.50	.74	.59	.63	.52	1.86	98.14	.562	0.0172	0.1311
90	.65	.78	.87	.73	.91	.76	2.61	97.39	.788	0.0088	0.0939
80	.60	.90	.81	.66	.83	.73	3.35	96.65	.760	0.0125	0.1119
70	.65	.93	.91	1.06	.95	.85	4.20	95.80	.900	0.0183	0.1354
60	1.35	1.55	1.68	1.39	1.51	1.47	5.66	94.34	1.496	0.0139	0.1179
50	2.10	2.14	2.54	2.19	2.23	2.21	7.87	92.13	2.240	0.0244	0.1563
40	3.94	3.24	4.18	4.10	3.42	3.81	11.68	88.32	3.776	0.1418	0.3766
30	6.94	7.30	7.00	6.67	7.46	7.05	18.73	81.27	7.074	0.0773	0.2781
20	6.60	6.64	6.40	6.71	6.65	6.60	25.33	74.67	6.600	0.0112	0.1060
10	12.82	12.93	12.29	13.04	12.24	12.70	38.03	61.97	12.664	0.1112	0.3335
10	63.22	61.46	60.70	61.40	61.49	61.97	100.00	.00	61.654	0.6983	0.8356
8	7.02	7.41				7.15			7.215	0.0380	0.1950
6	37.95	34.62				36.92			36.285	2.7722	1.6650
4	6.05	9.02				6.97			7.535	2.2052	1.4850
2	11.60	10.19				11.16			10.895	0.4970	0.7050
2	.59	.22				.48			.405	0.0342	0.1850
Arithmetic Average (Microns)									16.29		
Geometric Average									16.07		

TABLE II. HERCULES HMX 961-5E

Sieve Size (microns)	Weight % Retained: Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Combined Analysis	% Coarser Than Sieve Size	% Finer Than Sieve Size	Weight % Retained: Arithmetic Mean	Variance	Standard Deviation
180	.36	.26	.47	.41	.24	.35	.35	99.65	.348	0.0077	0.0875
150	.35	.36	.42	.48	.28	.28	.72	99.28	.378	0.0046	0.0676
130	.41	.40	.54	.52	.38	.45	1.17	98.83	.450	0.0044	0.0663
100	.37	.54	.55	.60	.42	.48	1.65	98.35	.496	0.0075	0.0864
90	.57	1.12	.71	.82	.72	.77	2.42	97.58	.788	0.0339	0.1841
80	.54	.70	.68	.69	.53	.62	3.04	96.96	.628	0.0058	0.0763
70	.50	.99	.77	.62	.60	.68	3.71	96.29	.696	0.0291	0.1705
60	.70	.96	1.11	1.01	.55	.85	4.56	95.44	.866	0.0433	0.2081
50	.66	.82	.98	.97	.76	.82	5.38	94.62	.838	0.0151	0.1230
40	.91	1.46	1.23	1.02	.92	1.09	6.47	93.53	1.108	0.0442	0.2103
30	2.07	2.13	2.27	2.16	1.90	2.10	8.57	91.43	2.106	0.0148	0.1218
20	3.31	3.60	3.49	3.64	3.45	3.48	12.04	87.96	3.498	0.0137	0.1169
10	14.54	13.27	14.09	14.52	13.72	14.08	26.13	73.87	14.028	0.2355	0.4853
10	74.72	73.40	72.69	72.54	75.54	73.87	100.00	0.00	73.778	1.3703	1.1706
8	9.06	1.01							7.535	2.3256	1.5250
6	38.45	47.65							43.05	21.600	4.6000
4	13.01	4.27							8.640	19.0967	4.3700
2	13.69	14.61							14.150	.2116	.4600
2	.57	.85							.68	0.0289	0.1700
Arithmetic Average (microns)									11.01		
Geometric Average									10.83		

TABLE III. HERCULES HMX L/N 148-61

Sieve Size (microns)	Weight % Retained Analysis 1	Analysis 2	Analysis 3	Analysis 4	Analysis 5	Combined Analysis	% Coarser Than Sieve Size	% Finer Than Sieve Size	Weight % Retained Arithmetic Mean	Variance	Standard Deviation
180	2.44	1.55	1.89	2.27	1.95	2.04	2.04	97.96	2.020	0.0963	0.3104
150	3.94	4.60	4.15	4.41	4.63	4.34	6.38	93.62	4.346	0.0705	0.2655
130	3.87	4.11	4.27	3.95	4.12	4.05	10.43	89.56	4.064	0.0197	0.1402
100	12.04	12.05	12.02	12.24	12.23	12.12	22.56	77.44	12.116	0.0095	0.0977
90	9.77	9.42	9.86	9.79	9.83	9.74	32.30	67.70	9.734	0.0256	0.1601
80	6.90	6.47	5.96	6.02	6.97	6.44	38.74	61.26	6.464	0.1795	0.4236
70	6.28	7.19	7.37	7.01	6.46	6.86	45.60	54.396	6.862	0.1776	0.4214
60	12.11	11.36	11.86	11.46	11.65	11.68	57.29	42.71	11.688	0.0737	0.2715
50	6.03	5.96	6.08	6.75	6.39	6.27	63.55	36.45	6.242	0.0861	0.2935
40	9.79	8.94	8.71	9.05	8.95	9.09	72.65	27.35	9.088	0.1356	0.3683
30	6.10	6.54	6.68	6.39	6.68	6.47	79.11	20.89	6.478	0.0472	0.2173
20	3.59	4.12	4.30	3.56	3.75	3.84	82.95	17.05	3.864	.0872	0.2953
10	4.02	4.24	4.17	3.96	4.10	4.09	87.04	12.96	4.098	0.0101	0.1005
10	13.12	13.46	12.69	13.14	12.28	12.96	100.00	0.0060	12.938	0.1682	0.4101
8	1.46				1.22				1.340	0.0144	0.1200
6	3.41				5.16				4.285	0.7656	0.8750
4	2.46				1.98				2.220	0.0576	0.2400
2	5.68				3.74				4.710	0.9409	0.9700
2	0.11				.18				.145	0.0012	0.0350
Arithmetic Average									69.49		
Geometric Average									69.14		

SIEVE ANALYSIS

Sieve analysis has been widely used in measuring particle size distribution (π) and is used in this case because of the ease with which a relatively large sample can be characterized.

HMX is ideal for sieving in that size and shape are appropriate. Many explosives have particle shapes that do not allow proper separation but HMX is slightly elliptical and often ranges from 350 to 10μ in size. HMX Π's are derived by sieving the powder through a nest of sieves and from the weight retained, weight percent is calculated. Quite often additional information is desired and thus study can be made in which sieve intervals can be used to better estimate distribution means and specific surface area. In order to gain a valid estimate of particle distributions, the principles of sieve analysis should be understood, e.g., effects of particle shape, orientation, dynamic locking, sieve loading, etc., on particle retention. Some principles of sieve analysis are discussed herein.

DISCUSSION

Sieve analysis has been considered by many analysts as the most rapid and easiest method to obtain a π. Basically, sieve analysis is the placing of a standard in the path of a moving particle which acts as a means of resistance by which particles are measured through retainment or passage. Ideally this means that particles greater than the sieve aperture are retained and those passing must be smaller than the aperture; thus, the ultimate goal is to segregate particles above or below a given aperture. The simplicity of these concepts gives the general idea that sieve analysis is simple, but to achieve accuracy and precision it can become extremely complicated.

Sieve analysis is usually performed by using a series of sieves having different size apertures, one upon the other, with the aperture size increasing upward in the vertical direction. The sample is placed on the upper sieve, which has the largest opening. The entire stack of sieves (nest) is then shaken and/or washed with an elutant until the sample distributes itself on the individual sieves. Theoretically, it appears that each particle has found its remaining sieve; however, this may not be true enough unless the inherent problems of sieving are eliminated. Inherent problems of sieving are as follows:

A. Electrostatic Adherence

Most powders generate static electricity when being sifted, thus fine particles adhere to the screen or each other, causing them to be deposited on screens that have apertures larger than their dimensions. This results in a shift in the distribution toward the coarser size. To eliminate this problem wet sieving is generally preferred and should be used with any powder having particle $<20\mu$. In wet sieving, high density moderate vapor pressure liquids are desired because of their flow properties. However, any liquid can be used that does not dissolve the particles to be sieved or react with the sieve's construction.

B. Particle Agglomeration

Agglomeration, due to weak bonding, must be eliminated before an accurate sieve analysis can be made. Wet sieving is preferred in that the agglomerated particles may be dispersed in an elutant by shaking or ultrasonic vibration before sieving. For powders difficult to disperse, wetting agents may be added to the elutant to assure adequate surface wetting.

C. Particle Abrasion

For brittle particles it has been found that repeated collision with the sieve surface or other particles tend to fracture particles causing a reduction in particle size. When excessive sieve time is required to separate particles, wet sieving is generally used to reduce impact velocity. If ultrasonic vibration is used to separate particle agglomerates a maximum duration must be determined, because ultrasonic vibration can fracture and abrade particles.

D. Sieve Abrasion

When sieving particles which are harder than the metals of the sieve construction, abrasion occurs which will increase the sieve's apertures. In sieving these powders a minimum sieving time should be used and frequent calibration of the sieves made. Extreme care should be used when washing and cleaning sieves in that the fragile construction of the mesh can be damaged, resulting in an alteration of the sieve's openings.

E. Sieve Apertures

For proper sieve analysis the openings of an individual sieve should be as accurate and alike as possible, because off-size apertures, as is apparent, will pass or retain particles less or greater than the nominal sieve size causing improper segregation of these particles. Thus, distributions generated from these sieves do not relate to the actual powder distribution. Wire woven sieves have apertures that vary as much as 15% (and with continued use the variance in aperture size increases). Electroformed sieves are far superior to wire woven sieves in that the variance in sieve apertures is generally quite small. In the larger aperture electroformed sieves the variance is ± 2μ, in the smaller sieves (<) 20μ), it is ± 1μ. Electroformed sieves have greatly improved the accuracy of determing powder distributions.

F. Nest Distributions

An adequate number of sieves must be used to determine the powder distribution and mode intervals. Many powders have been found which exist with more than one mode. Thus initial testing should be done with as many sieves as possible to find the major modes and then sieves not pertinent to bracket these modes may be eliminated. Bracketing sieves are important in reducing sieve load for major sieves, e.g., to prevent overloading.

G. Inclined Screening

The effective opening of sieves can be reduced by placing the sieve in an inclined position. Pitch on an inclined screen reduces the actual opening to a smaller effective opening due to the angle at which particles carried by gravity will strike the aperture. Inclining the screen should be avoided when accurate sieving analysis are to be made.

H. Dynamic Locking

Dynamic locking is due to the motion of the screen. In sieving powders, particles are normally in motion about the screen surface. If not, particle stoppage can occur regardless of particle size, after the initial motion of the particles to the sieve surface, unless an aperture is found. Thus the sieves are normally shaken, oscillated, thumped, etc., to place the particles in motion about the sieve to eliminate clogging. Sieve movement which is necessary has also been found to be critical as to speed and direction. Speed is important in that a rapid horizontally moving sieve has a tendency to present to a falling particle a grid instead of an opening. With slow horizontal movement a particle has a greater probability of finding a sieve aperture before the end of the operation. When a particle becomes stationary on the sieve surface (occasionally due to frictional forces) this particle tends to ride the surface. When a particle is frictionally bound, the particle and sieve proceed in the same direction at the same speed. Therefore, the screen must be moved at a speed so that frictional binding is overcome. Direction now becomes important and is basically of two kinds: (1) horizontal, which means the sieve moves perpendicular to the particle's normal gravitation direction, (2) vertical movement, which is intended to agitate and mix the particles by tossing them above the sieve. Fahrenwald and Stockdale (*1*) carried out an intensive study of the above sieve motions and found that machines using horizontal movement were not as efficient as those using vertical movement.

I. Sieve Blinding Due to Overloading

Overloading of sieves leads to inaccurate results because of improper segregation of particles due to aperture blockage by oversize particles. During sieving two major passages occur: (1) fines easily pass the aperture, and (2) some particles just pass the sieve aperture. The fines pass quite rapidly, unless overloading occurs; and thus the bulk of the sieving time is related to the passage of those particles which just pass a sieve aperature.

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(1) *Effects of Sieve Motions on Screening Efficiency, Bureau of Mines, Serial Number 2933, May 1929.*

For a near-mesh particle close to the aperture sieve, orientation to the aperture is critical for passage and, it must usually be continually lifted from the sieve surface and presented again to another portion of the sieve surface. Because a powder layer on a sieve is several particles thick, then the probability of a near-mesh particle finding an unoccupied aperture is quite small. Thus, mixing and presenting the particles to the sieve would be an endless process in order to get every particle to pass those sieves larger than the particle's dimensions. Prolongation of sieving time does improve the probability that a near-mesh particle finds an aperture for passage; however, if overloading occurs the probability decreases again, because of particles being trapped between other particles. Overloading therefore is not related to gross amount added to a sieve, but to the proportion that does not pass through the sieve readily. The sample size should be set by this factor. It should also be kept in mind that prolongation for segregation in sieving time may not improve particle passage as much as reduction in sample size. The ASTM method of sample size restricts the amount of material retained by a specific sieve to be less than a certain weight per square inch of sieving surface. This weight varies for specific materials and is a function of density, which essentially restricts the number of particles per sieve to avoid aperture masking.

J. Sieving Time

Sieving time has been generally regulated by one of three criteria.

1. By standard time of sieving. This method has been adopted by the British Bureau of Standards #12,1931. When using this method one normally predetermines time required for adequate separation by observing retention after various times by microscopy.

2. By stating that sieving must be continued until the weight of powder passing the sieve per minute is less than a certain percent of the total weight of the sample taken (American Standard 1926D).

3. By stating that sieving must be continued until the weight of material passing the sieve per run is less than a certain proportion of the weight retained on that sieve.

Method 3 is the better method, although in wet sieving it is more complicated. However, it does set limits on the retaining material which takes into account near-mesh particles.

These three methods of determining end points are widely used and any of them would give reproducibility, which is important. Most analysts state that complete separation is not possible; therefore set sieving time at

a point where most of the readily passable particles have passed and where the passing rate of near-mesh size is small. To be safe a near-mesh particle count should be made to determine that failure to pass is not due to overloading. A general procedure to follow on new material analysis is to use one of the old test procedures and see where the modes occur. Check the retained powder on the major mode sieves by microscopy to see how many undersize particles have been retained. Then determine if the retainment of fines is due to insufficient sieving time or overloading. Large numbers of readily passable particles means overloading and large numbers of near-mesh particles is usually due to insufficient duration. From this test sample nest size and sieving time can usually be determined.

K. Aperture Shape

Sieves of several kinds have been used, e.g., those having round, rectangular slits, or square openings. Square openings are generally favored because there is less orientation effect. Square openings reduce the corridors found in slitted screens. (In a square of 20μ the corridor along the diagonal will allow up to 28μ to pass if their L/W or W/H ratio is favorable; the effect with slits is obvious.) Round openings were introduced to eliminate corridor effects. For rectangular and cubic particles round openings do not adequately represent the restricting particle dimensions in that a round opening requires a diameter that equals the diagonals and not side dimensions. Round openings are best suited for spherical particles, but square openings relate to spherical diameter anyway. The additional opening area afforded by square openings speeds sphere passage, e.g., in wet sieving by increasing elutant flow.

L. Particle Retainment

If we consider a single square aperture perpendicular to the approach of a particle then the factors involved in retention have to do with all the dimensions of the particles. Retainment may be due to each of its dimensions separately or in combination, forming a diagonal. For a single rectangular particle many combinations can cause retainment; the parameter that does so is sometimes called the approach dimension.

Approach dimensions vary according to the shape of the particles; spheres have but one dimension(obviously the diameter of the sphere) while cubes have one side or diagonals that can cause stoppage.

When a particle has dimensions such that length > width > depth then several approach dimensions must be taken into account. For example, particles having length 85% of the corridor length an L/W ratio of $\sim$ 5.8 is required for corridor passage. In order for a particle having length 99% of the corridor length to pass a L/W ratio of 39.0 would be necessary. Thus it can be seen that extremely high L/W ratios are required for corridor passage and that orientation is critical.

Irregularly shaped particles gain more corridor passage, as particle dimensions become more varied; the powder analysis likewise becomes more varied.

The sieving of irregularly shaped particles tend to be more governed by the laws of chance and reproducibility of such distributions are often poor.

M. Angle of Approach

Mesh thickness does not appear important in particle passage, except that elutant flow may be decreased by the thicker mesh and should be avoided if possible. If the mesh thickness is not too great high angles of approach (angle between the direction of fall and the vertical) do not increase flow impedance much.

In order to study dimension effects on sieve analysis, a sample of HMX was sieved in duplicates and from the powder retained on each sieve, samples were removed for microscopy analysis. By measuring particle dimensions for the various particles found retained on the sieves, segregation according to approach dimension were studied. In addition to the material retained on the sieves, upon drying a small percentage of particles are found to fall through the sieves; the particles that passed thus upon elutant drying were also measured.

In this study the primary dimensions analyzed were length and width. From Table IV, the effectiveness of the sieving time and sample size can be seen: only 0.6% of the particles retained on each sieve had both width and length less than the retaining aperature.

When sieving analysis is done wet, each sieve must be dried before the weight of material retained can be determined. After drying, particles have been found beneath the sieves. From all indications the majority of the particles passing were near-mesh size and only 4.3% had both dimensions less than the passing aperture.

COMMENTS AND CONCLUSIONS

Sieve analysis, an extremely useful method in describing π for some kinds of particles should be performed in a manner which avoids the inherent problems involved in sieving. Wet sieving has been found by our laboratory to be far more reproducible when sieving particles below 2000μ in size. Wet sieving reduces particle attrition due to impact upon the sieve surface and with other particles. Deagglomeration by use of ultrasonic vibration while the sample is in a liquid is very helpful in that the sample is placed on the sieves while wet so that agglomeration does not recur. Ultrasonic vibration does change particle size when done for an excessive length of time, therefore a maximum time must be determined for each specific material to be sieved. Elutants are frequently used as a solvent for binders in formulated materials and should be selected on the basis of the best solvent for binders

Table IV. HMX Analysis

Sieve Cuts

Sieve Size	Particles Measured	Particles with Length > Top Aperture	Particles with Length < Bottom Aperture	Particles with Width > Top Aperture	Particles with Width < Bottom Aperture	Particles with Width > Top Corridor	Particles Retained with Both Dimensions < Bottom Aperture
180	894		11	125			11
%			1.23	13.92			1.23
150	867	839	2	142	83	0	2
%		96.77	.23	16.38	9.57	0.00	.23
130	889	871	9	172	103	2	9
%		97.97	1.01	19.35	11.59	.22	1.01
100	913	882	4	305	65	1	4
%		96.60	.44	33.41	7.12	.11	.44
90	862	855	4	591	80	2	4
%		99.19	.46	68.56	9.28	.23	.46
80	901	873	14	635	124	2	14
%		96.89	1.55	70.48	13.76	.22	1.55
70	845	827	6	373	167	0	6
%		97.87	.71	44.14	12.66	0.00	.71
60	819	804	4	395	100	2	4
%		98.17	.49	48.22	12.21	.24	.49
50	922	914	4	435	88	1	4
%		99.13	.43	47.18	9.54	.11	.43
40	919	910	3	310	126	2	3
%		99.02	.33	33.73	13.71	.22	.33
30	935	927	1	362	29	8	1
%		99.14	.11	38.73	3.10	.86	.11
20	949	933	3	253	86	0	3
%		98.31	.32	26.66	9.06	0.00	.32
10	909	792	5	63	96	0	5
%		87.13	.55	6.93	10.56	0.00	.55
< 10	899	13		1	0		
%		1.45		.11		0.00	
	$\bar{x}$	89.7%	.60	35.98	9.40	.17	.60

Table V.

Particles Passed After Sieving

Sieve Size	Particles Passed	Having Length > Passing Aperture	Having Length > Passing Corridor	Particles Having Width > Passing Aperture	Particles with Width < Passing Aperture	Particles with Width > Passing Corridor	Particles with Both Dimensions < Passing Aperture or Corridor	Particles Width < Passing Corridor
180	85	85	74	70	15	45	0	40
%		100.00	87.06	82.35	17.65	52.94	0.00	47.06
150	58	52	47	45	13	8	6	50
%		89.66	81.03	77.59	22.41	13.79	10.34	86.21
130	174	166	141	136	38	3	8	171
%		95.40	81.03	78.16	21.84	1.72	4.60	98.28
100	213	205	149	136	77	6	8	207
%		96.24	69.95	63.85	36.15	2.82	3.76	97.18
90	183	183	31	151	32	8	0	175
%		100.00	16.94	82.51	17.49	4.37	0.00	95.63
80	356	339	226	171	185	5	17	351
%		95.22	63.48	48.03	51.97	1.40	4.78	98.60
70	489	449	256	163	326	0	40	489
%		91.82	52.35	33.33	66.67	0.00	8.18	100.00
60	236	227	127	88	148	1	9	235
%		96.19	53.81	37.29	62.71	.42	3.81	99.58
50	107	99	69	61	46	1	8	106
%		92.52	64.49	57.01	42.99	.93	7.48	99.07
40	118	118	112	98	20	8	0	110
%		100.00	94.92	83.05	16.95	6.78	0.00	93.22
30								
%	$\bar{x}$	95.70%	66.51	64.31	33.50	8.52	4.30	

that do not react with the material to be sieved and the sieve. Elutants should be presaturated before use so that it does not act as a solvent for the material to be sieved. When the elutant is used as a solvent for formulated material the elutant should be frequently changed so that upon drying the elutant does not leave a residue.

Sieve analysis should not be performed on material that has a length/width ratio greater than about 2 because the reliability of describing such a powder's π is not good. Sample size should be based upon the amount of material retained on each sieve and those that retain the most should be thoroughly studied to determine if retainment is due to overloading. Additionally, sieves that retain the most material of near-mesh size should be observed to determine sieving time.

Automatic Sieving Apparatus

Particle size work at Pantex has been concerned with developing relatively efficient, accurate and reproducible methods of characterizing particulate explosive materials. One method developed at Pantex and adopted by various agencies has been wet sieve analysis ranging from 2000 to 1μ. Due to powder distributions being in the 180μ and below range, a nest 180 through 10μ electroform sieves are required for a standard distribution analysis. In order to conveniently perform a wet sieve analysis an instrument was devised to perform this test.

While using the sieving procedure, the motions needed to get a good analysis were studied to help give a clue to the agitation modes that would be needed for a sieve washer. The study revealed three motions were needed to avoid "blinding," etc. and to obtain fast, reproducible results. These were: (1) rotation; (2) a thumping action (vertical agitation); and (3) a slight vibration action on the side of the sieves. These motions were incorporated into the sieve washer shown in Fig. 1.

This apparatus was designed to hold two stacks of 14 electroformed sieves. The controls for the different agitation modes are contained in the panel on the right of the apparatus. Point "A" marks the controls for the rotation of the sieves. The vibration is introduced to the sieves by two means: (1) a vibrator "H" whose controls are mounted at "B" and (2) a set of tappers at "E" with controls at point "C". The vibrator "H" may be positioned at any of the 17 positions on bar "D" to get the most efficient vibration into the sieves; also, the tappers may be removed or added to get the most efficient combination.

The regulators and speed adjustment are shown mounted on the control panel for each mode of agitation. This instrument has capabilities of horizontal motion obtained through the side motion of the entire sieve carriage and is not used due to overflow and a disadvantageous particle action.

The elutant is introduced into the sieves at "I" through a spray nozzle mounted in the cover over the sieves. The elutant is kept in a tank connected to the sieve washer at point "F", a flow control value.

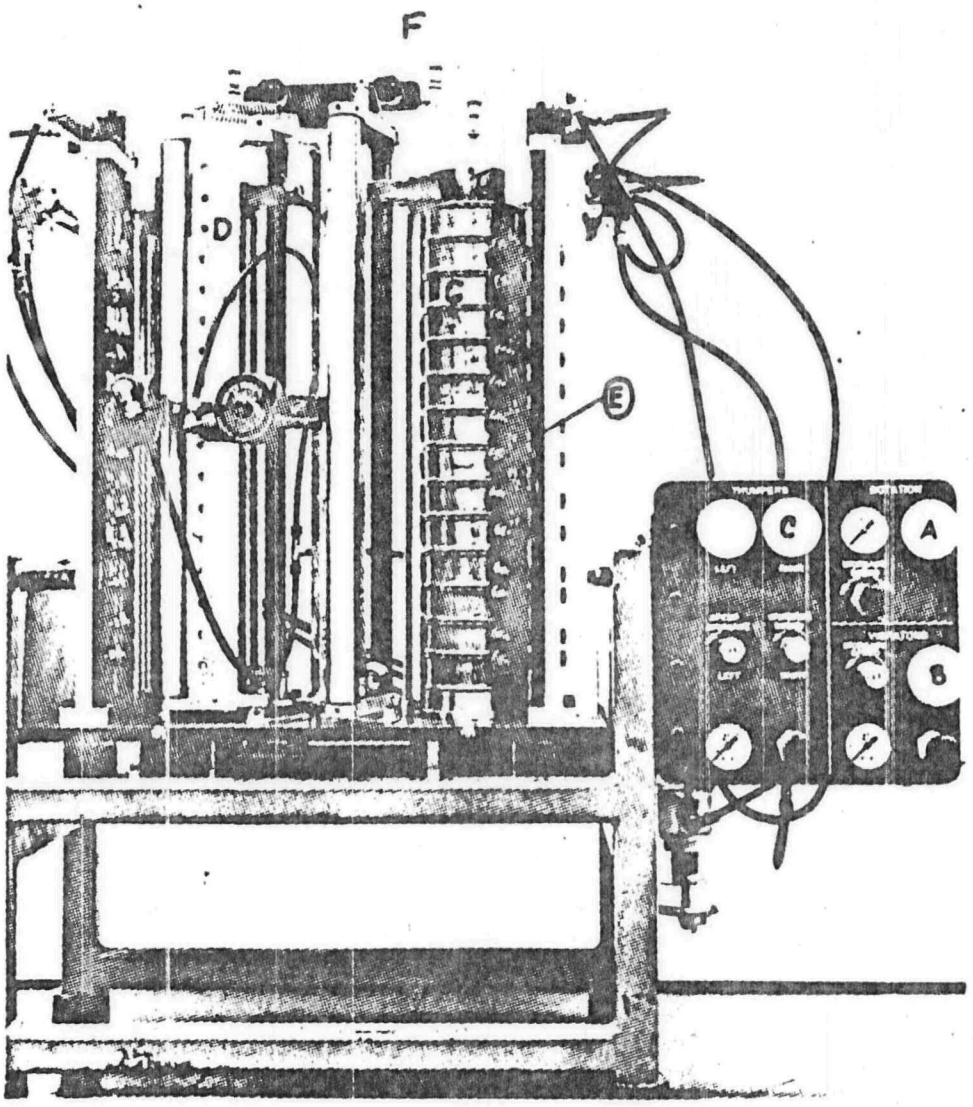


Figure 1. Pantex sieve washer with 14 sieves on one side. Control panel for the vibration and rotation modes of agitation shown at the left.

Many experiments have been performed with this apparatus to find the sieving end-point at several control settings. A complete set of experiments to obtain control settings and flow rates were carried out.

The sieves used in the above-mentioned procedure, and in the sieve washer, need to have a small hole drilled in the side to prevent an elutant lock in the stack. Fig. 2 shows the preparation needed for the sieves; that is, crimp in the bottom lip and a hole in the top. This is needed to obtain a correct flow rate through the sieves.

The following procedure will describe the technique for sieving HMX. The apparatus meter settings will be covered in Part A and sample preparation, elutant, and sieving

A. Apparatus Meter Settings

1. Pressure settings

(a) Rotation - approximately 60 psi

(b) Vibration - approximately 60 psi

(c) Tapper - approximately 35 psi (about 450 cpm)

(d) Elutant Tank - approximately 3 psi

2. Elutant Flow 170 to 200 ml/min.

B. Procedure

1. Preparation of Sample

(a) Dry sample in vacuum oven for at least 2 hours to remove moisture.

(b) Place the sample in approximately 150 ml of isobutyl acetate saturated with HMX.

(c) Put the sample in the ultrasonic vibrator until there are no visible signs of agglomerate (no longer than 5 minutes because of crystal destruction after this period). If periods of ultrasonic vibration are longer than 5 minutes in order to disperse sample then pre-shaking may be necessary. A wrist-action shaker does not damage the particles and extended time in the elutant does not seem to be detrimental.

(d) Keep the sample well agitated and covered until used.

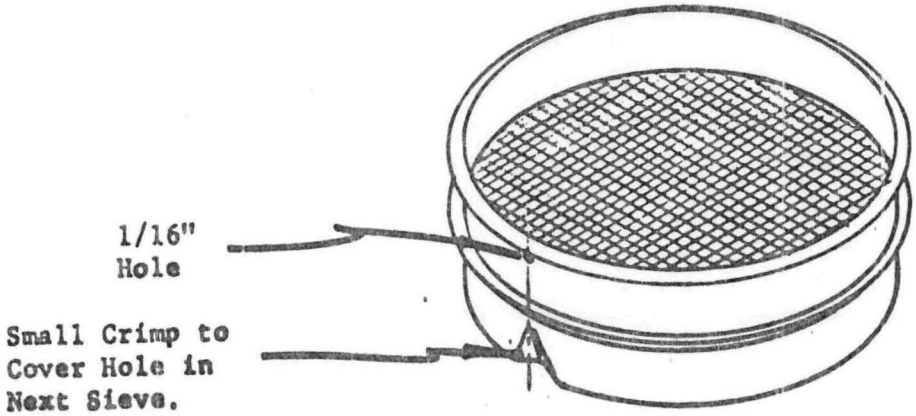


Figure 2. Position of Hole in Sieve

2. Preparation of Elutant

(a) Isobutyl acetate should be saturated with HMX for at least 24 hours before filtering.

(b) During HMX saturation if a dispersant is used then it should also be added before filtering so proper saturation of HMX may be accomplished.

(c) Saturate isobutyl acetate at temperature used for sieving.

(d) Filter the elutant to remove excessive HMX and dispersant.

(e) After filtering avoid evaporation and temperature change.

3. Procedure for Sieving

(a) Place the weighted sieves (180 to 10μ) in a stack on the Pantex Sieving Apparatus.

(b) Turn on rotation and vibration.

(c) Pour the sample through the stack of sieves.

(d) Wash sample container with 50 to 75 ml of elutant as soon as possible.

(e) Turn on tappers and place cover over the sieve stack. Turn tappers on as soon as possible after putting sample in stack so the elutant does not build up on 10 and 20μ sieve.

(f) After most of initial elutant has passed 10μ sieve turn on elutant flow.

(g) Pass about 1300 ml of elutant through the sieve stack.

(h) Turn off vibrators

(i) Additional elutant will pass through with rotation and tappers on. When flow ceases turn off tappers and rotation.

(j) Remove sieves and inspect for HMX splashed on sides and bottom of sieves. When necessary wash down the sides with a squeeze bottle and wash all HMX on the bottom of the sieve into the lower sieve. This may accumulate some elutant which may be removed by agitation.

(k) Centrifuge all elutant passing 10μ sieves.

(l) Dry sieves and centrifuge tubes in vacuum oven until all isobutyl acetate is removed.

(m) Weigh sieves and centrifuge tubes.

(n) Calculate as percent retained or as percent passing.

4. Preparation of Freon B.F. for use as an elutant for the 2, 4, 6 and 8 sieves

   (a) Using a given volume of Freon B.F., add 10% isobutyl acetate.

   (b) Add ∿ 1 gram "Thixcin R" to each 500 ml of solution and saturate on wrist action shaker for 20 minutes.

   (c) Saturate with HMX and filter with No. 42 Whatman filter paper.

5. Procedure for Sieving with 2, 4, 6 and 8 sieves.

   (a) Take a sample of the HMX that has been centrifuged and dried. (Retained as <10μ)
   (b) Weigh the total sample (may already have weight).

   (c) From this sample, weigh out approximately 0.4 grams of HMX and put in 25 ml of Freon B.F. in a weighted flask.

   (d) Place the solution with HMX into ultrasonic vibrator and agitate until agglomerates have been broken apart (approximately 3 minutes).

   (e) Place the 10, 8, 6, 4, 2μ sieves on the sieve washer.

   (f) Pour the HMX and solution into the 10μ sieve and start washing the HMX through the sieves. Tap on the side of the sieves to prevent clogging. Weigh the HMX residue and beaker. Keep covered with lid or size large sieve to prevent evaporation.

   (g) Wash the HMX in each sieve thoroughly as previously described for the >10μ. However elutant is added by squeezing bottle. Total added 100 to 200 ml.

   (h) Centrifuge the material from the solution passing the 2μ sieve.

   (i) Dry and weigh sieves and centrifuge tubes.

   (j) Repeat steps (a) through (i) for two additional 0.4 gram samples from the large sample of HMX for repeats if necessary.

Ultrasonic Vibration

Due to the severe agitation action of the ultrasonic vibrator, HMX crystals have been found to shatter and grind into smaller particles. Two experiments performed (June 1964) clearly show the attrition of HMX particles by prolonged ultrasonic vibration. The first experiment was to collect 5 grams of Class A HMX being retained on various sieves and then agitated in the vibrator for various times; the second was to use two HMX lots subjected to four different treatments in the vibrator.

The first experiment was carried out as follows: Lot 591-63 was sieved and 5 grams of HMX collected for the 250, 177, 125, 105, 88, 74, 62 and 44μ sieves. Each 5 grams of HMX was placed in a 125 ml flask with 100 ml of elutant and vibrated for thirty minutes in 5 minute increments. The results indicate that particle attrition is dependent on size and duration. These results are shown in Fig. 3. Since coarser particles are the most effected, ∿60% of the original 250μ particles reduced in size during the first 5 minutes. Another study was made to see the effects in 1 minute increments. The results are shown in Fig. 4; they indicate that the minimum time should be used.

The second experiment was set up with the following treatments for two undistributed batches:

1. Standard treatment of 5 minutes in ultrasonic @ 35 ma and flask on tank bottom.

2. Flask suspended in tank, shaken with wrist-action shaker while ultrasonic vibrator apparatus operates @ 30 ma for 2 minutes.

3. Violent ultrasonic vibrator action @ 50 ma for 15 minutes

4. Wrist action shaker for 5 minutes.

The results are shown in Fig. 5 and 6; they show that the greatest distribution change occurred during treatment #3. Microscopy indicated adequate dispersion of agglomerates achieved with treatments #1 and #2, while treatment #3 shatters the particles and #4 does not adequately disperse agglomerates.

Fig. 3. HMX Particle Attrition During Various Ultrasonic Vibration Times as Function of Particle Size

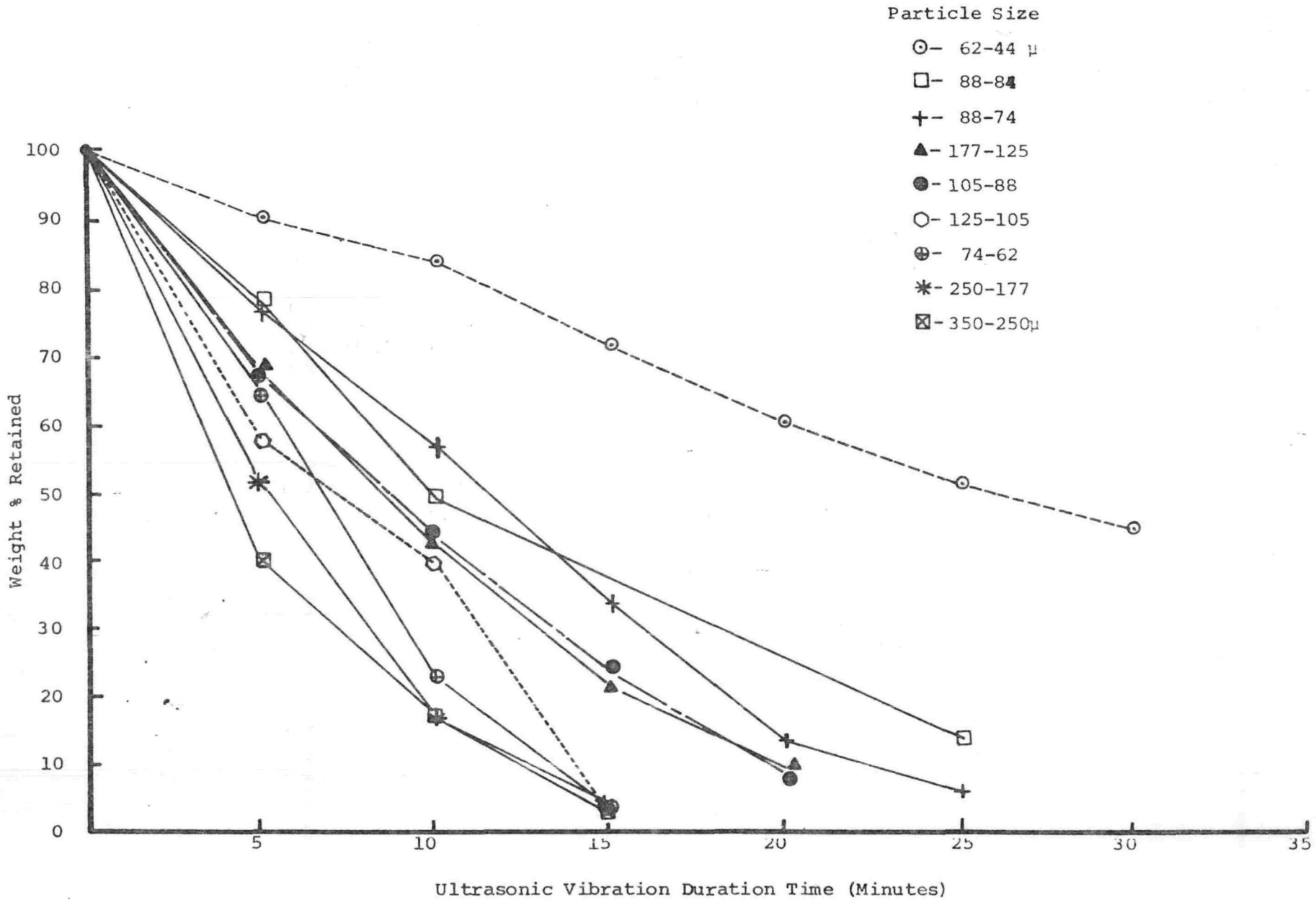
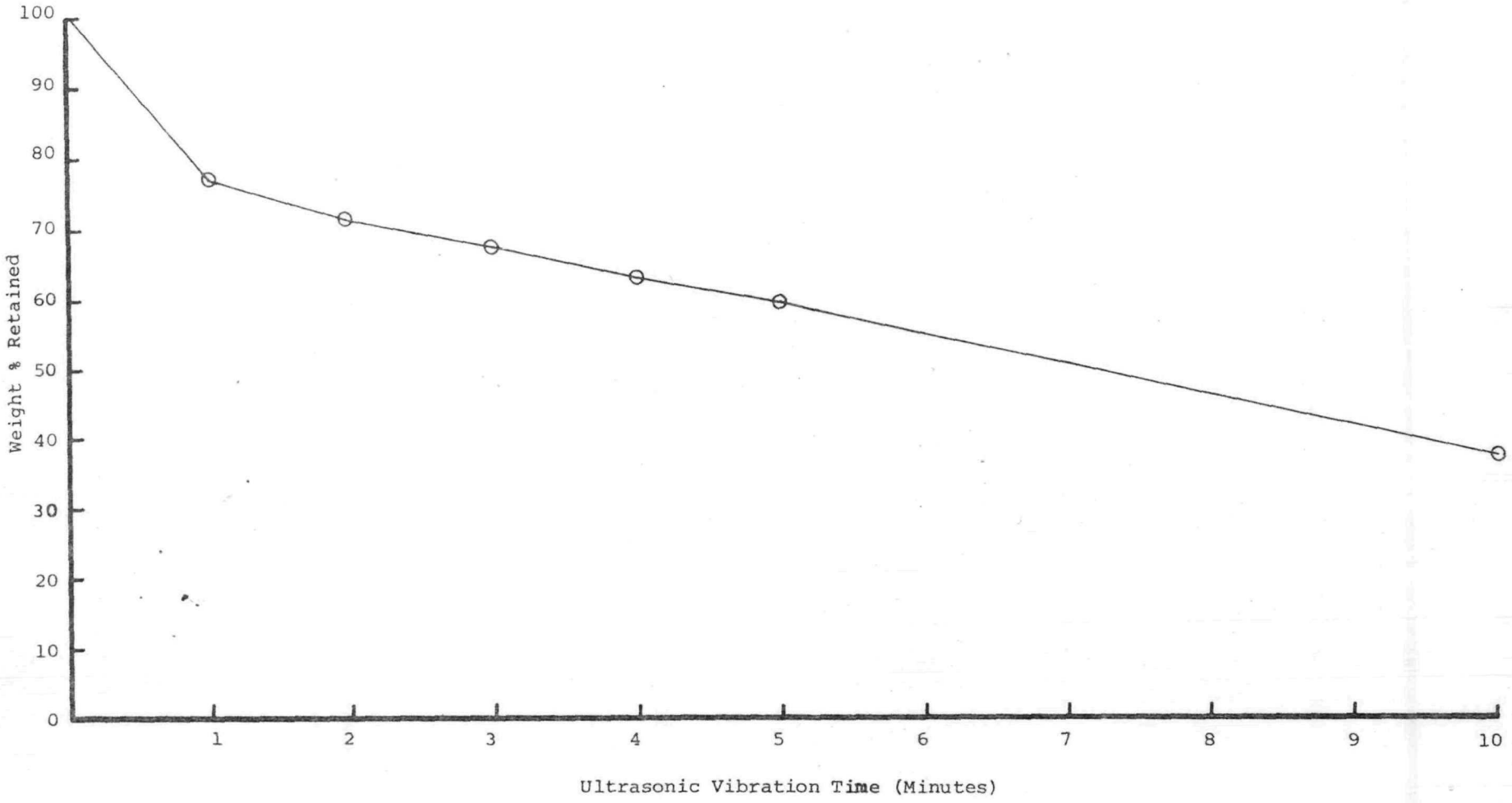
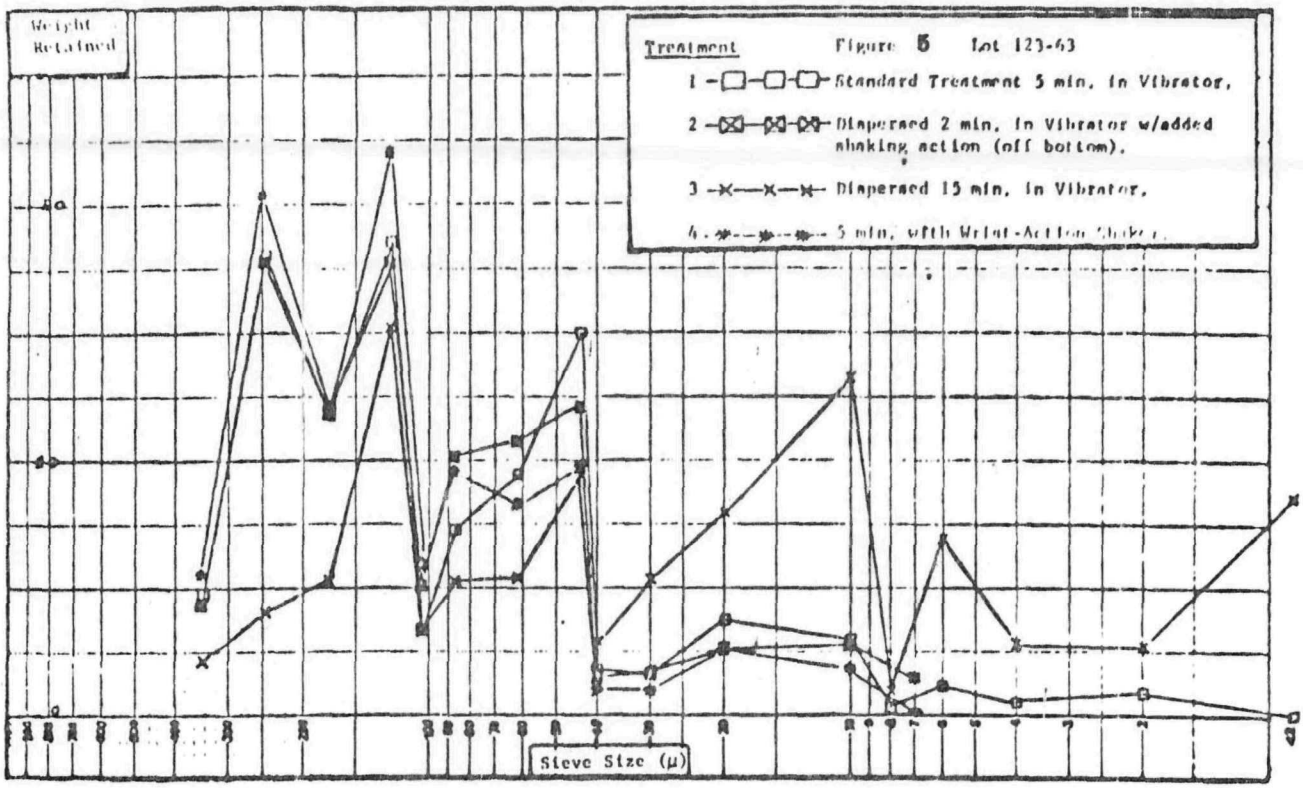
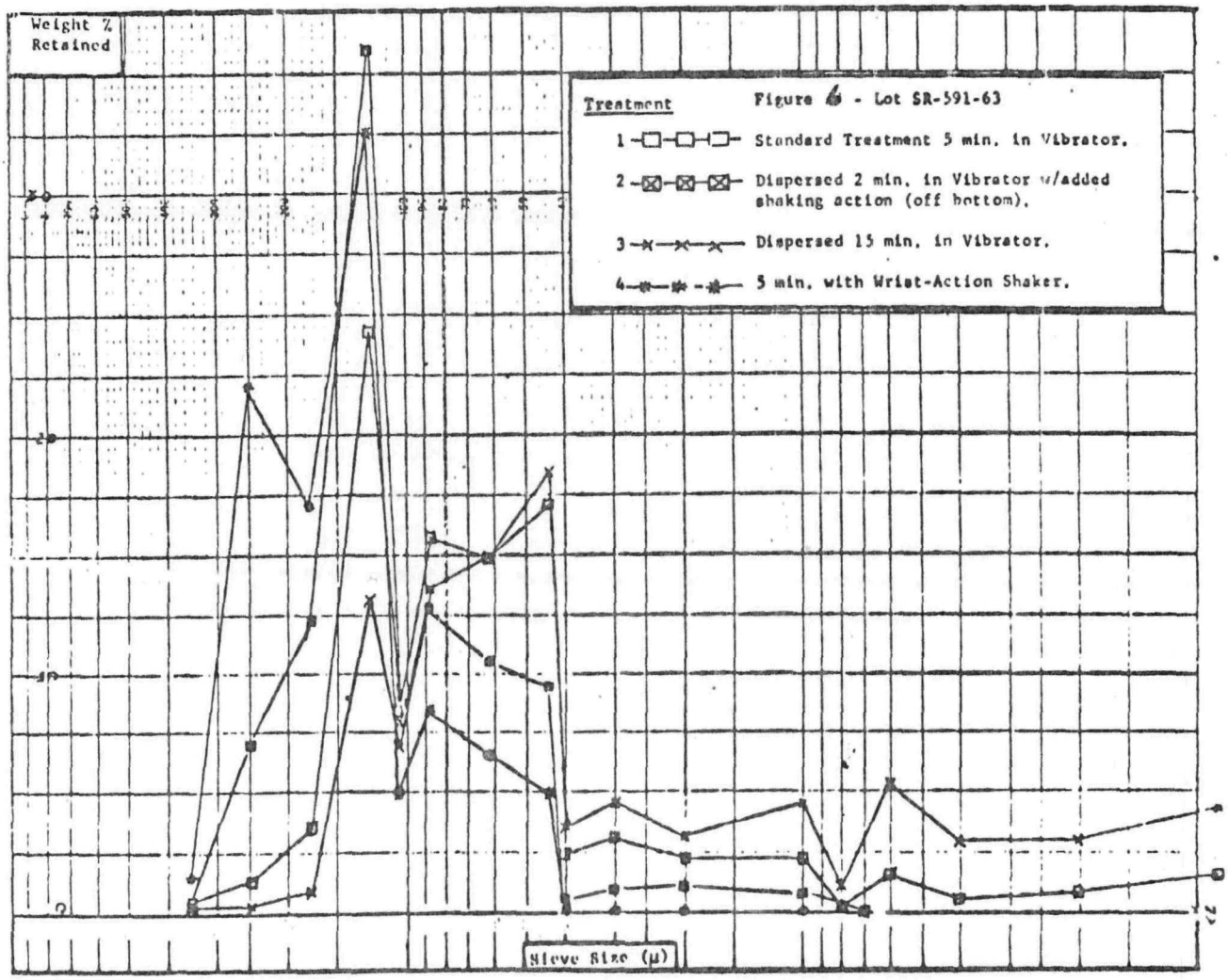


Fig. 4. HMX Passing 105μ retained on 74μ sieve and subjected to different times in ultrasonic vibrator.




Weight Retained
Treatment
Figure 5 Lot 123-63
1 Standard Treatment 5 min. in Vibrator.
2 Dispersed 2 min. in Vibrator w/added shaking action (off bottom).
3 Dispersed 15 min. in Vibrator.
4 5 min. with Wrist-Action Shaker.
Sieve Size (μ)


Weight % Retained
Treatment
Figure 6 - Lot SR-591-63
1 Standard Treatment 5 min. in Vibrator.
2 Dispersed 2 min. in Vibrator w/added shaking action (off bottom).
3 Dispersed 15 min. in Vibrator.
4 5 min. with Wrist-Action Shaker.
Sieve Size (μ)

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 961-5 E

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

NO OF SIEVE ANALYSES = 1
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 2

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9791	77.9876
150	81.1302	81.1418
130	79.5839	79.5970
100	78.6729	78.6904
90	80.7288	80.7654
80	80.9937	81.0164
70	81.0242	81.0565
60	82.0564	82.0898
50	81.5646	81.5913
40	80.2376	80.2850
30	81.4280	81.4972
20	80.0283	80.1455
10	80.9327	81.3646
CENTRIFUGE		
1	43.9635	46.3530
SIEVE SIZE (MICRON)		
8	78.5858	78.6062
6	78.6696	78.8314
4	77.7948	77.8093
2	77.0344	77.0840
CENTRIFUGE		
1	11.0523	11.0552

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 961-5 E

CRYSTAL DENSITY : 1.9000 G/CM**3

DATE : 09/08/72

NO OF SIEVE ANALYSES = 1
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 2

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9791	77.9876
150	81.1302	81.1418
130	79.5839	79.5970
100	78.6729	78.6904
90	80.7288	80.7654
80	80.9937	81.0164
70	81.0242	81.0565
60	82.0564	82.0898
50	81.5646	81.5913
40	80.2376	80.2850
30	81.4280	81.4972
20	80.0283	80.1455
10	80.9327	81.3646
CENTRIFUGE		
1	43.9635	46.3530
SIEVE SIZE (MICRON)		
8	78.5858	78.6062
6	78.6696	78.8314
4	77.7948	77.8093
2	77.0344	77.0840
CENTRIFUGE		
1	11.0523	11.0552

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 961-5 E

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

SIEVE SIZE (MICRON)	ANALYSIS 1 WEIGHT RETAINED (GRAM)	ANALYSIS 1 WEIGHT % RETAINED	ANALYSIS 1 ACCUM. WEIGHT % RETAINED	ANALYSIS 2 WEIGHT RETAINED (GRAM)	ANALYSIS 2 WEIGHT % RETAINED	ANALYSIS 2 ACCUM. WEIGHT % RETAINED	COMBINED ANALYSIS DIFF IN WEIGHT %	COMBINED WT. RET. (GRAM)	COMBINED WEIGHT % RETAINED	PERCENT COARSER THAN	PERCENT FINER THAN
180	0.0135	0.41	0.41	0.0077	0.24	0.24	0.173	0.0212	0.32	0.32	99.68
150	0.0158	0.48	0.89	0.0092	0.28	0.52	0.197	0.0250	0.38	0.70	99.30
130	0.0173	0.52	1.41	0.0123	0.38	0.89	0.147	0.0296	0.45	1.15	98.85
100	0.0199	0.60	2.01	0.0136	0.42	1.31	0.186	0.0335	0.51	1.66	98.34
90	0.0272	0.82	2.84	0.0235	0.72	2.03	0.104	0.0507	0.77	2.44	97.56
80	0.0227	0.69	3.52	0.0173	0.53	2.56	0.157	0.0400	0.61	3.05	96.95
70	0.0206	0.62	4.15	0.0197	0.60	3.16	0.020	0.0403	0.61	3.66	96.34
60	0.0332	1.01	5.15	0.0178	0.55	3.71	0.460	0.0510	0.78	4.44	95.56
50	0.0319	0.97	6.12	0.0247	0.76	4.47	0.209	0.0566	0.86	5.30	94.70
40	0.0336	1.02	7.14	0.0300	0.92	5.38	0.098	0.0636	0.97	6.27	93.73
30	0.0714	2.16	9.30	0.0619	1.90	7.28	0.268	0.1333	2.03	8.29	91.71
20	0.1201	3.64	12.93	0.1128	3.45	10.74	0.181	0.2329	3.55	11.84	88.16
10	0.4797	14.52	27.46	0.4481	13.72	24.46	0.798	0.9278	14.13	25.97	74.03
<10	2.3963	72.54	100.00	2.4663	75.54	100.00	-2.995	4.8626	74.03	100.00	0.00
ARITH MEAN	10.2711			8.2526				9.2677			
GEOM. MEAN	10.0992			8.0952				9.1031			

	ANALYSIS 1	ANALYSIS 2
ELUDTANT USED	ISOBUTYL ACETATE	ISOBUTYL ACETATE
METHOD OF SIEVING	PANTEX AUTOWASH	PANTEX AUTOWASH
SIEVING TIME-MIN	25.	25.0
ULTRASONIC VIB TIME-MIN	1.0	1.0
SAMPLE WEIGHT-GRAM	5.0166 ≥WET≤	5.0013 ≥WET≤
TYPE OF SIEVES USED	ELECTRO FORM	ELECTRO FORM

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 961-5 E

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

NO OF SIEVE ANALYSES = 2
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 1

NO OF SUB-ANALYSES FOR ANALYSIS 2 = 1

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9833	77.9968
150	81.1337	81.1495
130	79.5901	79.6074
100	78.6768	78.6967
90	80.7310	80.7582
80	80.9989	81.0216
70	81.0263	81.0469
60	82.0614	82.0946
50	81.5663	81.5982
40	80.2395	80.2731
30	81.4341	81.5055
20	80.0314	80.1515
10	80.9394	81.4191
CENTRIFUGE		
1	43.9542	46.3505

ANALYSIS 2

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9791	77.9868
150	81.1300	81.1392
130	79.5848	79.5971
100	78.6775	78.6861
90	80.7285	80.7520
80	80.9955	81.0128
70	81.0240	81.0437
60	82.0585	82.0753
50	81.5632	81.5879
40	80.2376	80.2676
30	81.4285	81.4904
20	80.0290	80.1418
10	80.9341	81.3822
CENTRIFUGE		
	43.9665	46.4328

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 961-5 E

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

SIEVE SIZE (MICRON)	ANALYSIS 1 WEIGHT RETAINED (GRAM)	ANALYSIS 1 WEIGHT % RETAINED	ANALYSIS 1 ACCUM. WEIGHT % RETAINED	ANALYSIS 2 WEIGHT RETAINED (GRAM)	ANALYSIS 2 WEIGHT % RETAINED	ANALYSIS 2 ACCUM. WEIGHT % RETAINED	COMBINED ANALYSIS DIFF IN WEIGHT %	COMBINED WT. RET. (GRAM)	COMBINED ANALYSIS WEIGHT % RETAINED	COMBINED ANALYSIS PERCENT COARSER THAN	COMBINED ANALYSIS PERCENT FINER THAN
180	0.0184	0.36	0.36	0.0154	0.47	0.47	-0.109	0.0338	0.40	0.40	99.60
150	0.0183	0.35	0.71	0.0140	0.42	0.89	-0.069	0.0323	0.38	0.78	99.22
130	0.0211	0.41	1.12	0.0177	0.54	1.42	-0.127	0.0388	0.46	1.24	98.76
100	0.0192	0.37	1.49	0.0182	0.55	1.98	-0.179	0.0374	0.44	1.68	98.32
90	0.0294	0.57	2.06	0.0236	0.71	2.69	-0.144	0.0530	0.63	2.31	97.69
80	0.0277	0.54	2.60	0.0226	0.68	3.37	-0.147	0.0503	0.59	2.90	97.10
70	0.0257	0.50	3.10	0.0253	0.77	4.14	-0.267	0.0510	0.60	3.50	96.50
60	0.0362	0.70	3.80	0.0367	1.11	5.25	-0.409	0.0729	0.86	4.36	95.64
50	0.0341	0.66	4.46	0.0323	0.98	6.23	-0.317	0.0664	0.78	5.15	94.85
40	0.0469	0.91	5.37	0.0407	1.23	7.46	-0.323	0.0876	1.03	6.18	93.82
30	0.1066	2.07	7.43	0.0751	2.27	9.73	-0.207	0.1817	2.15	8.33	91.67
20	0.1706	3.31	10.74	0.1154	3.49	13.22	-0.186	0.2860	3.38	11.71	88.29
10	0.7505	14.54	25.28	0.4658	14.09	27.31	0.448	1.2163	14.36	26.07	73.93
<10	3.8570	74.72	100.00	2.4027	72.69	100.00	2.035	6.2597	73.93	100.00	0.00
8	0.4676	9.06	34.34								
6	1.9845	38.45	72.78								
4	0.6717	13.01	85.80								
2	0.7069	13.69	99.49								
<2	0.0263	0.51	100.00								
ARITH MEAN	13.1236			10.3487				9.2555			
GEOM. MEAN	12.8901			10.1807				9.0899			

ELUDTANT USED	ISORUTYL ACETATE	ISOBUTYL ACETATE
METHOD OF SIEVING	PANTEX AUTOWASH	PANTEX AUTOWASH
SIEVING TIME-MIN	25.0	25
ULTRASONIC VIB TIME-MIN	1.0	1.0
SAMPLE WEIGHT-GRAM	8.0006 ≥WET≤	5.0340 ≥WET≤
TYPE OF SIEVES USED	ELECTRO FORM	ELECTROFORM

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 961-5 E

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

NO OF SIEVE ANALYSES = 2
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 2

NO OF SUB-ANALYSES FOR ANALYSIS 2 = 1

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9864	78.0048
150	81.1350	81.1533
130	79.5941	79.6152
100	78.6801	78.6993
90	80.7328	80.7622
80	81.0030	81.0307
70	81.0278	81.0535
60	82.0632	82.0994
50	81.5687	81.6028
40	80.2426	80.2895
30	81.4340	81.5406
20	80.0318	80.2024
10	80.9459	81.6964
CENTRIFUGE		
1	43.9320	47.7850
SIEVE SIZE (MICRON)		
8	78.5865	78.6078
6	78.6675	78.7579
4	77.7927	77.8233
2	77.0324	77.0646
CENTRIFUGE		
1	11.0506	11.0518

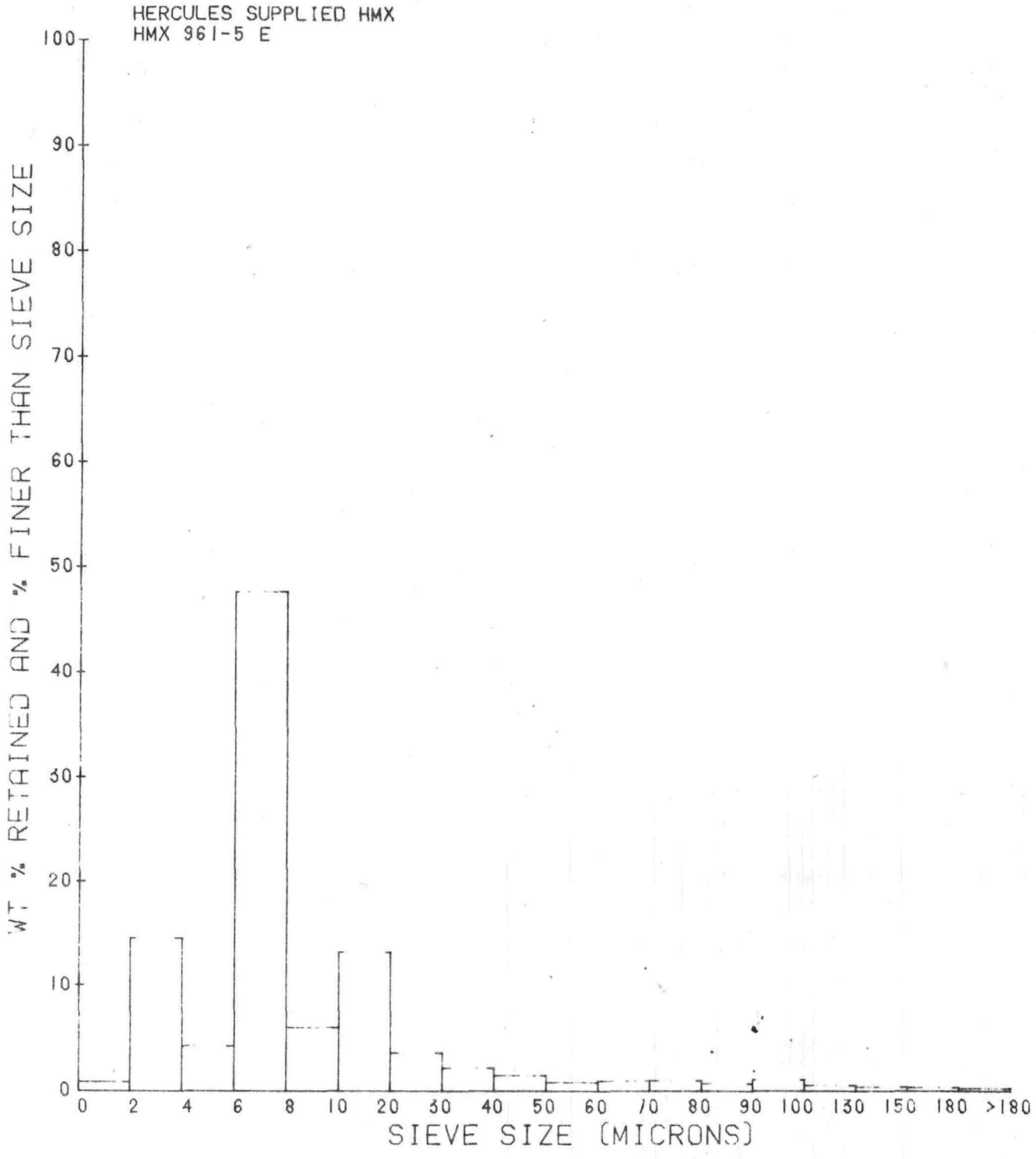
ANALYSIS 2

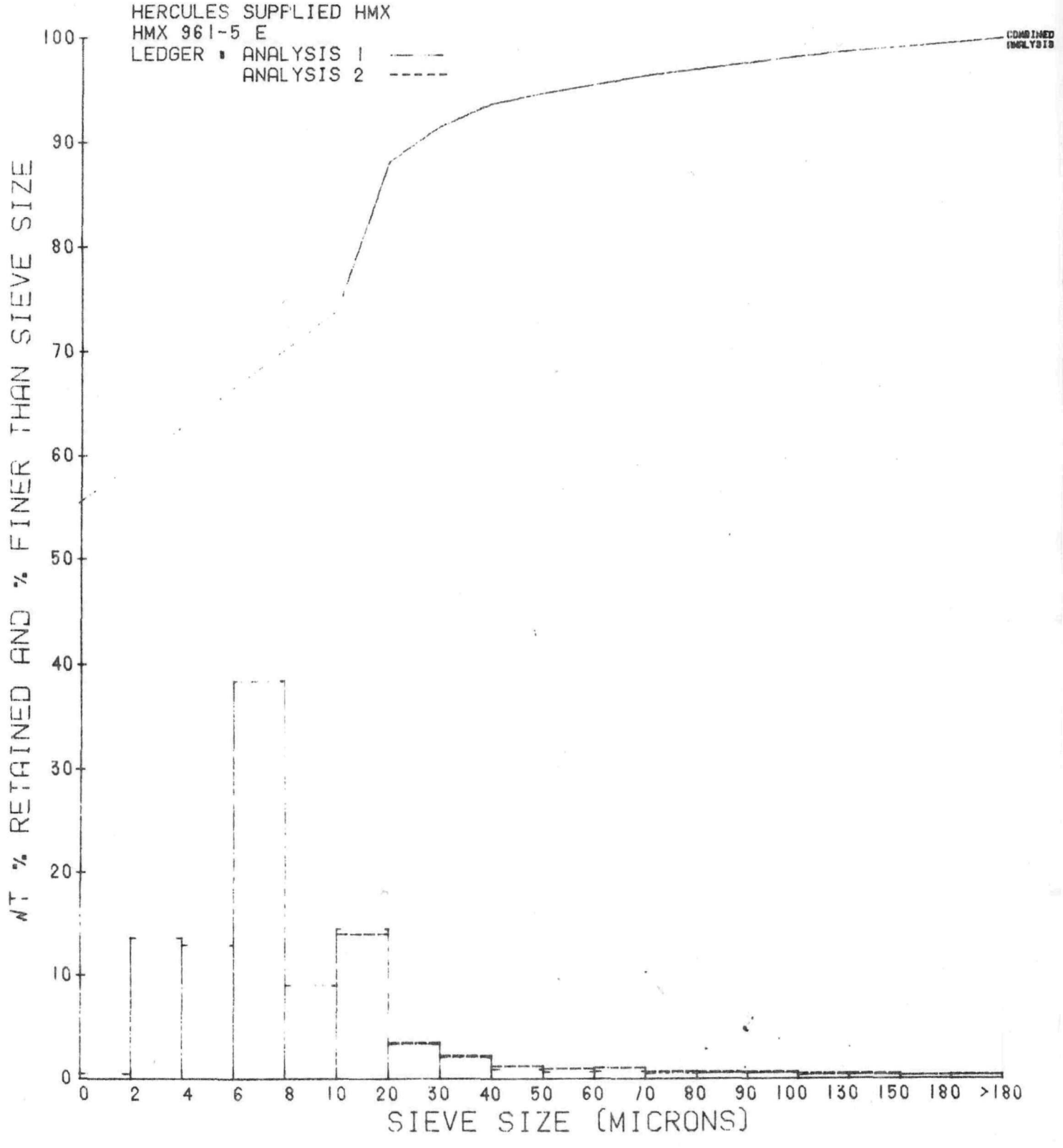
SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9764	77.9918
150	81.1268	81.1408
130	79.5845	79.6022
100	78.6702	78.6884
90	80.7244	80.7480
80	80.9954	81.0180
70	81.0205	81.0438
60	82.0556	82.0943
50	81.5444	81.5839

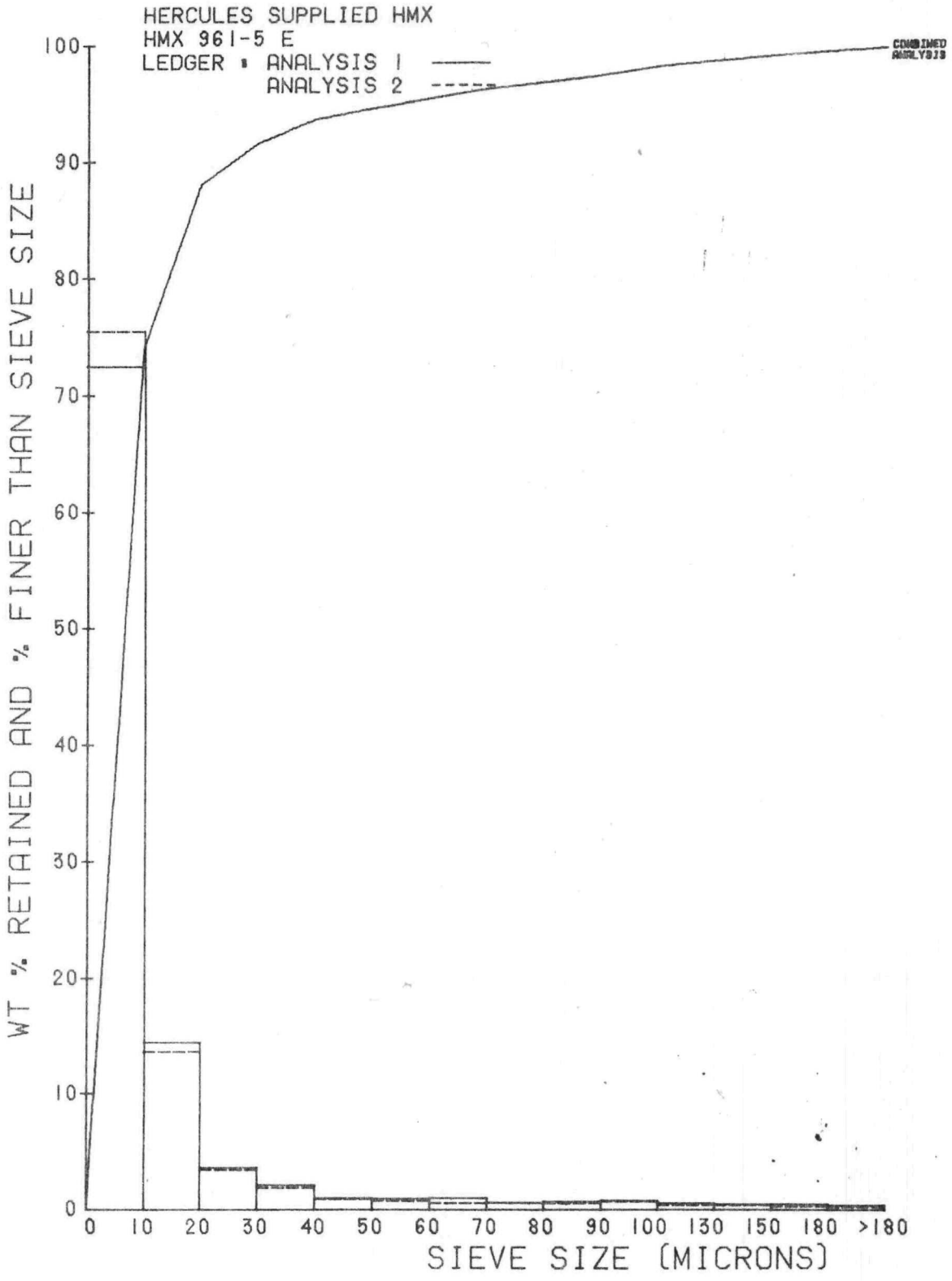
50	[illegible]	[illegible]
40	80.2359	80.2766
30	81.4278	81.5029
20	80.0281	80.1435
10	80.9369	81.4027

CENTRIFUGE

1	43.9450	46.3477


HERCULES SUPPLIED HMX
HMX 961-5 E
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 2 4 6 8 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)


HERCULES SUPPLIED HMX
HMX 961-5 E
LEDGER ▪ ANALYSIS 1
ANALYSIS 2
COMBINED ANALYSIS
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 2 4 6 8 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)


HERCULES SUPPLIED HMX
HMX 961-5 E
LEDGER • ANALYSIS 1
ANALYSIS 2
COMBINED ANALYSIS
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

ANALYSIS 1

SIEVE SIZE (MICRON)	WEIGHT RETAINED (GRAM)	WEIGHT % RETAINED	PERCENT COARSER THAN
180	0.0197	0.50	0.50
150	0.0239	0.60	1.10
130	0.0231	0.58	1.68
100	0.0251	0.63	2.31
90	0.0362	0.91	3.23
80	0.0330	0.83	4.06
70	0.0376	0.95	5.01
60	0.0601	1.51	6.52
50	0.0884	2.23	8.75
40	0.1357	3.42	12.17
30	0.2959	7.46	19.62
20	0.2638	6.65	26.27
10	0.4856	12.24	38.51
<10	2.4398	61.49	100.00

ARITH MEAN 15.5711
GEOM. MEAN 15.3718

II-1

ELUDTANT USED ISOBUTYL ACETATE

METHOD OF SIEVING PANTEX AUTOWASH

SIEVING TIME-MIN 25.0

ULTRASONIC VIB TIME-MIN 1.0

SAMPLE WEIGHT-GRAM 5.0346 (WET)

TYPE OF SIEVES USED ELECTRO FORM

ENCLOSURE II

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

NO OF SIEVE ANALYSES = 1
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 1

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9760	77.9957
150	81.1265	81.1504
130	79.5824	79.6055
100	78.6710	78.6961
90	80.7249	80.7611
80	80.9923	81.0253
70	81.0214	81.0590
60	82.0547	82.1148
50	81.5609	81.6493
40	80.2360	80.3717
30	81.4229	81.7188
20	80.0275	80.2913
10	80.9342	81.4198
CENTRIFUGE		
1	43.9468	46.3866

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

SIEVE SIZE (MICRON)	ANALYSIS 1 WEIGHT RETAINED (GRAM)	ANALYSIS 1 WEIGHT % RETAINED	ANALYSIS 1 ACCUM. WEIGHT % RETAINED	ANALYSIS 2 WEIGHT RETAINED (GRAM)	ANALYSIS 2 WEIGHT % RETAINED	ANALYSIS 2 ACCUM. WEIGHT % RETAINED	COMBINED ANALYSIS DIFF IN WEIGHT %	COMBINED WT. RET. (GRAM)	COMBINED WEIGHT % RETAINED	PERCENT COARSER THAN	PERCENT FINER THAN
180	0.0217	0.56	0.56	0.0188	0.48	0.48	0.079	0.0405	0.52	0.52	99.48
150	0.0235	0.61	1.17	0.0177	0.45	0.93	0.153	0.0412	0.53	1.05	98.95
130	0.0278	0.72	1.88	0.0201	0.51	1.45	0.203	0.0479	0.62	1.66	98.34
100	0.0287	0.74	2.62	0.0232	0.59	2.04	0.147	0.0519	0.67	2.33	97.67
90	0.0337	0.87	3.49	0.0286	0.73	2.77	0.138	0.0623	0.80	3.13	96.87
80	0.0315	0.81	4.31	0.0259	0.66	3.44	0.150	0.0574	0.74	3.87	96.13
70	0.0353	0.91	5.22	0.0416	1.06	4.50	-0.154	0.0769	0.99	4.86	95.14
60	0.0651	1.68	6.90	0.0542	1.39	5.89	0.293	0.1193	1.53	6.39	93.61
50	0.0984	2.54	9.43	0.0855	2.19	8.08	0.351	0.1839	2.36	8.75	91.25
40	0.1619	4.18	13.61	0.1604	4.10	12.18	0.072	0.3223	4.14	12.89	87.11
30	0.2712	7.00	20.61	0.2608	6.67	18.85	0.323	0.5320	6.83	19.73	80.27
20	0.2482	6.40	27.01	0.2622	6.71	25.56	-0.306	0.5104	6.56	26.28	73.72
10	0.4766	12.29	39.30	0.5095	13.04	38.60	-0.742	0.9861	12.67	38.95	61.05
<10	2.3530	60.70	100.00	2.3998	61.40	100.00	-0.705	4.7528	61.05	100.00	0.00
ARITH MEAN	16.3229			14.9922				15.6549			
GEOM. MEAN	16.1215			14.7890				15.4525			

	ANALYSIS 1	ANALYSIS 2
ELUDTANT USED	ISOBUTYL ACETATE	ISOBUTYL ACETATE
METHOD OF SIEVING	PANTEX AUTOWASH	PANTEX AUTOWASH
SIEVING TIME-MIN	25.0	25
ULTRASONIC VIB TIME-MIN	1.0	1.0
SAMPLE WEIGHT-GRAM	5.0018 ≥WET•	5.0151 ≥WET•
TYPE OF SIEVES USED	ELECTRO FORM	ELECTRO FORM

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

NO OF SIEVE ANALYSES = 2
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 1

NO OF SUB-ANALYSES FOR ANALYSIS 2 = 1

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9846	78.0063
150	81.1345	81.1580
130	79.5921	79.6199
100	78.6780	78.7067
90	80.7316	80.7653
80	81.0011	81.0326
70	81.0265	81.0618
60	82.0627	82.1278
50	81.5664	81.6648
40	80.2398	80.4017
30	81.4340	81.7052
20	80.0314	80.2796
10	80.9431	81.4197
CENTRIFUGE		
1	43.9366	46.2896

ANALYSIS 2

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9758	77.9946
150	81.1258	81.1435
130	79.5821	79.6022
100	78.6707	78.6939
90	80.7256	80.7542
80	80.9922	81.0141
70	81.0210	81.0626
60	82.0554	82.1096
50	81.5611	81.6486
40	80.2359	80.3963
30	81.4272	81.6880
20	80.0272	80.2894
10	80.9339	81.4454
CENTRIFUGE		
1	43.9570	46.3568

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57

CRYSTAL DENSITY : 1.9000 G/CM**3

DATE : 09/08/72

	ANALYSIS 1			ANALYSIS 2			COMBINED ANALYSIS				
SIEVE SIZE (MICRON)	WEIGHT RETAINED (GRAM)	WEIGHT % RETAINED	ACCUM. WEIGHT % RETAINED	WEIGHT RETAINED (GRAM)	WEIGHT % RETAINED	ACCUM. WEIGHT % RETAINED	DIFF IN WEIGHT %	COMBINED WT. RET. (GRAM)	WEIGHT % RETAINED	PERCENT COARSER THAN	PERCENT FINER THAN
180	0.0238	0.27	0.27	0.0206	0.51	0.51	-0.243	0.0444	0.34	0.34	99.66
150	0.0221	0.25	0.51	0.0234	0.58	1.09	-0.331	0.0455	0.35	0.69	99.31
130	0.0225	0.25	0.76	0.0215	0.53	1.62	-0.280	0.0440	0.34	1.03	98.97
100	0.0317	0.35	1.12	0.0203	0.50	2.12	-0.147	0.0520	0.40	1.43	98.57
90	0.0579	0.65	1.77	0.0316	0.78	2.90	-0.133	0.0895	0.69	2.12	97.88
80	0.0541	0.60	2.37	0.0365	0.90	3.80	-0.297	0.0906	0.70	2.82	97.18
70	0.0583	0.65	3.02	0.0376	0.93	4.73	-0.277	0.0959	0.74	3.55	96.45
60	0.1211	1.35	4.37	0.0628	1.55	6.28	-0.198	0.1839	1.41	4.97	95.03
50	0.1881	2.10	6.48	0.0867	2.14	8.42	-0.039	0.2748	2.11	7.08	92.92
40	0.3527	3.94	10.42	0.1312	3.24	11.66	0.701	0.4839	3.72	10.81	89.19
30	0.6208	6.94	17.35	0.2956	7.30	18.96	-0.364	0.9164	7.05	17.86	82.14
20	0.5907	6.60	23.96	0.2690	6.64	25.61	-0.043	0.8597	6.61	24.47	75.53
10	1.1477	12.82	36.78	0.5235	12.93	38.54	-0.105	1.6712	12.86	37.33	62.67
<10	5.6577	63.22	100.00	2.4886	61.46	100.00	1.757	8.1463	62.67	100.00	0.00
8	0.6286	7.02	43.80	0.3001	7.41	45.95	-0.388	0.9288	7.15	44.47	55.53
6	3.3965	37.95	81.76	1.4019	34.62	80.57	3.330	4.7984	36.92	81.39	18.61
4	0.5411	6.05	87.80	0.3652	9.02	89.59	-2.973	0.9062	6.97	88.36	11.64
2	1.0383	11.60	99.41	0.4127	10.19	99.78	1.410	1.4510	11.16	99.52	0.48
<2	0.0532	0.59	100.00	0.0088	0.22	100.00	0.378	0.0619	0.48	100.00	0.00
ARITH MEAN	17.0128			19.0408				17.6445			
GEOM. MEAN	16.7600			18.7829				17.3902			

ELUDTANT USED	ISOBUTYL ACETATE	ISOBUTYL ACETATE
METHOD OF SIEVING	PANTEX AUTOWASH	PANTEX AUTOWASH
SIEVING TIME-MIN	25	25
ULTRASONIC VIB TIME-MIN	1.0	1.0
SAMPLE WEIGHT-GRAM	5.1539 (WET)	12.0027 (WET)
TYPE OF SIEVES USED	ELECTROFORM	ELECTROFORM

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/08/72

NO OF SIEVE ANALYSES = 2
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 2

NO OF SUB-ANALYSES FOR ANALYSIS 2 = 2

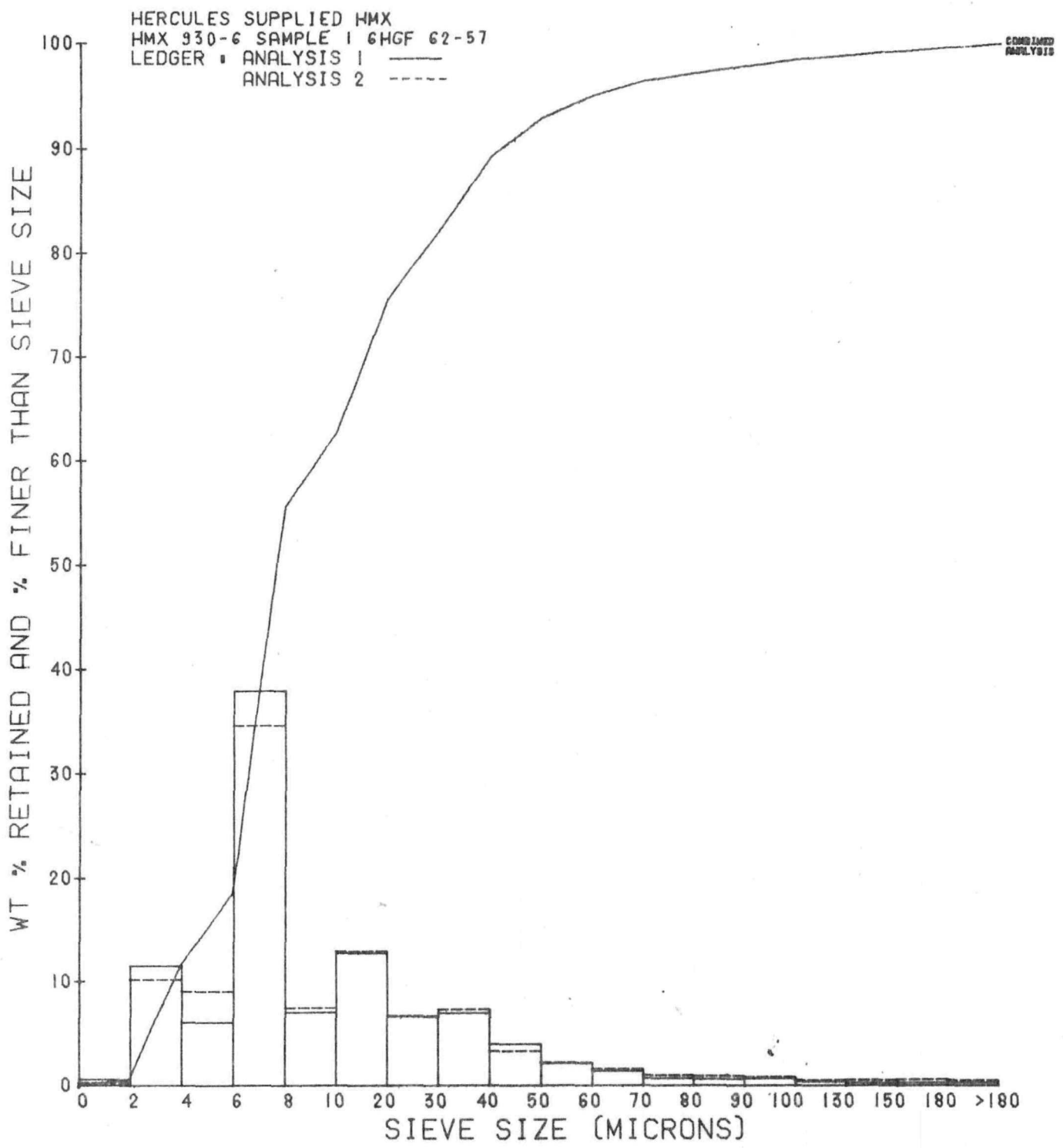
ANALYSIS 1

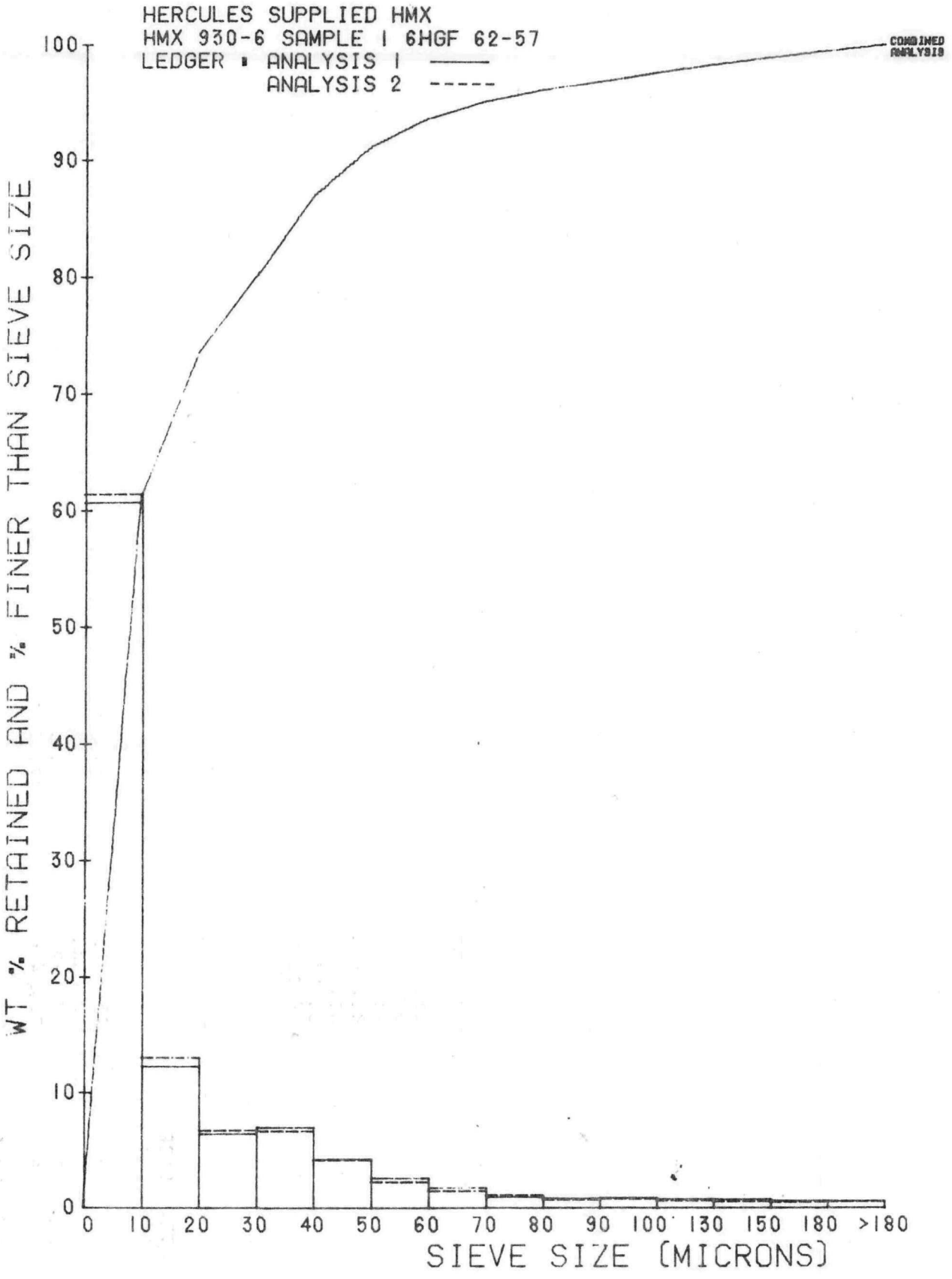
SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9864	78.0102
150	81.1350	81.1571
130	79.5941	79.6166
100	78.6801	78.7118
90	80.7328	80.7907
80	81.0030	81.0571
70	81.0278	81.0861
60	82.0632	82.1843
50	81.5687	81.7568
40	80.2426	80.5953
30	81.4340	82.0548
20	80.0318	80.6225
10	80.9459	82.0936
CENTRIFUGE		
1	43.9320	49.5897
SIEVE SIZE (MICRON)		
8	78.5875	78.6076
5	78.6699	78.7785
4	77.7948	77.8121
2	77.0340	77.0672
CENTRIFUGE		
1	11.0533	11.0550

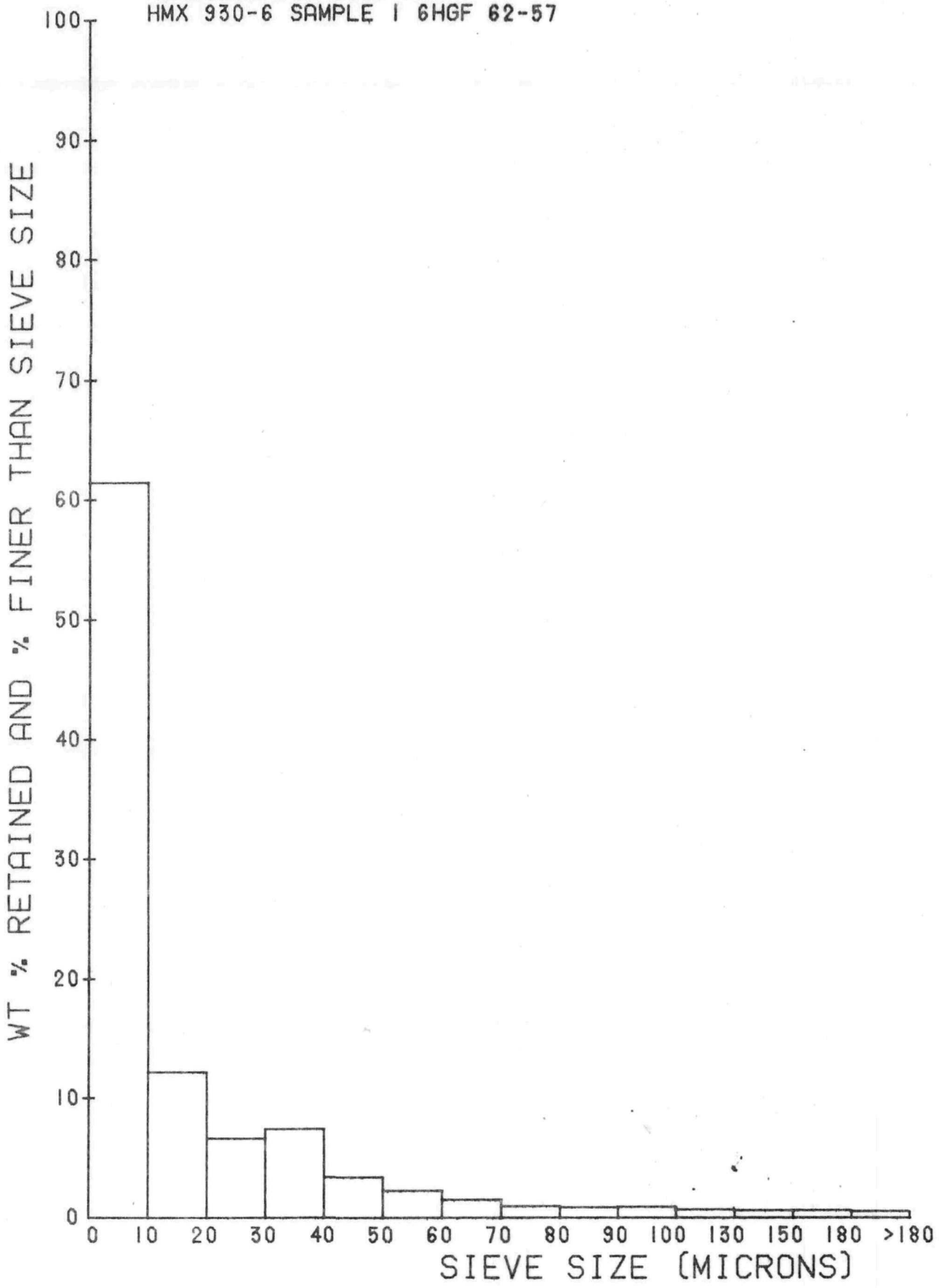
ANALYSIS 2

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9832	78.0038
150	81.1305	81.1539
130	79.5905	79.6120
100	78.6755	78.6958
90	80.7283	80.7599
80	80.9994	81.0359
70	81.0242	81.0618
60	82.0606	82.1234
50	81.5661	81.6528

50	81.9081	81.8348
40	80,2391	80,3703
30	81.4357	81.7313
20	80,0301	80,2991
10	80,9425	81,4660
CENTRIFUGE		
1	43,9348	46,4234
SIEVE SIZE (MICRON)		
8	78,5876	78,6116
6	78.6696	78.7817
4	77,7940	77,8232
2	77,0337	77,0667
CENTRIFUGE		
1	11,0523	11,0530


HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57
LEDGER ▪ ANALYSIS 1
ANALYSIS 2
COMBINED ANALYSIS
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 2 4 6 8 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)


HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE 1 6HGF 62-57
LEDGER ▪ ANALYSIS 1 ——
ANALYSIS 2 -----
COMBINED ANALYSIS
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)


HERCULES SUPPLIED HMX
HMX 930-6 SAMPLE I 6HGF 62-57
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED POWDER
HERCULES HMX L/N 148-61

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 08/25/72

ANALYSIS 1

SIEVE SIZE (MICRON)	WEIGHT RETAINED (GRAM)	WEIGHT % RETAINED	PERCENT COARSER THAN
180	0.2661	2.44	2.44
150	0.4297	3.94	6.38
130	0.4217	3.87	10.25
100	1.3127	12.04	22.29
90	1.0652	9.77	32.06
80	0.7528	6.90	38.97
70	0.6849	6.28	45.25
60	1.3199	12.11	57.35
50	0.6578	6.03	63.39
40	1.0669	9.79	73.17
30	0.6650	6.10	79.27
20	0.3909	3.59	82.86
10	0.4385	4.02	86.88
<10	1.4303	13.12	100.00
8	0.1588	1.46	88.34
6	0.3720	3.41	91.75
4	0.2684	2.46	94.21
2	0.6189	5.68	99.89
<2	0.0123	0.11	100.00

ARITH MEAN 68.9099
GEOM. MEAN 69.5630

ELUDTANT USED ISOBUTYL ACETATE

METHOD OF SIEVING PANTEX AUTOWASH

SIEVING TIME=MIN 20.

ULTRASONIC VIB TIME=MIN

SAMPLE WEIGHT=GRAM 13.4126

TYPE OF SIEVES USED ELECTROFORM

III-1

ENCLOSURE III

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED POWDER
HERCULES HMX L/N 148-61

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 08/25/72

NO OF SIEVE ANALYSES = 1
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 2

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9892	78.2553
150	81.1360	81.5657
130	79.5978	80.0195
100	78.6819	79.9946
90	80.7332	81.7984
80	81.0034	81.7562
70	81.0283	81.7132
60	82.0666	83.3865
50	81.5702	82.2280
40	80.2448	81.3117
30	81.4358	82.1008
20	80.0337	80.4246
10	80.9529	81.3914
CENTRIFUGE		
1	43.9370	45.3673
SIEVE SIZE (MICRON)		
8	78.5825	78.6032
6	78.6643	78.7128
4	77.7896	77.8246
2	77.0296	77.1103
CENTRIFUGE		
1	11.0492	11.0508

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX

~~HMX L/N 148-61~~

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/06/72

	ANALYSIS 1			ANALYSIS 2			COMBINED ANALYSIS				
SIEVE SIZE (MICRON)	WEIGHT RETAINED (GRAM)	WEIGHT % RETAINED	ACCUM. WEIGHT % RETAINED	WEIGHT RETAINED (GRAM)	WEIGHT % RETAINED	ACCUM. WEIGHT % RETAINED	DIFF IN WEIGHT %	COMBINED WT. RET. (GRAM)	WEIGHT % RETAINED	PERCENT COARSER THAN	PERCENT FINER THAN
180	0.1569	1.55	1.55	0.1942	1.89	1.89	-0.340	0.3511	1.72	1.72	98.28
150	0.4665	4.60	6.15	0.4270	4.15	6.04	0.451	0.8935	4.37	6.09	93.91
130	0.4163	4.11	10.26	0.4391	4.27	10.31	-0.161	0.8554	4.19	10.28	89.72
100	1.2214	12.05	22.30	1.2363	12.02	22.32	0.032	2.4577	12.03	22.31	77.69
90	0.9546	9.42	31.72	1.0148	9.86	32.18	-0.447	1.9694	9.64	31.95	68.05
80	0.6560	6.47	38.19	0.6129	5.96	38.14	0.514	1.2689	6.21	38.17	61.83
70	0.7289	7.19	45.38	0.7578	7.37	45.51	-0.175	1.4867	7.28	45.44	54.56
60	1.1517	11.36	56.74	1.2203	11.86	57.37	-0.500	2.3720	11.61	57.06	42.94
50	0.6047	5.96	62.71	0.6260	6.08	63.45	-0.120	1.2307	6.02	63.08	36.92
40	0.9062	8.94	71.64	0.8964	8.71	72.16	0.226	1.8026	8.82	71.91	28.09
30	0.6626	6.54	78.18	0.6869	6.68	78.84	-0.140	1.3495	6.61	78.51	21.49
20	0.4174	4.12	82.30	0.4426	4.30	83.14	-0.185	0.8600	4.21	82.72	17.28
10	0.4299	4.24	86.54	0.4293	4.17	87.31	0.068	0.8592	4.21	86.93	13.07
<10	1.3648	13.46	100.00	1.3052	12.69	100.00	0.777	2.6700	13.07	100.00	0.00
ARITH MEAN	68.4604			69.0100				68.7372			
GEOM. MEAN	68.1210			68.6719				68.3984			

ELUDTANT USED	ISOBUTYL ACETATE	ISOBUTYL ACETATE
METHOD OF SIEVING	PANTEX AUTOWASH	PANTEX AUTOWASH
SIEVING TIME-MIN	20.	20.0
ULTRASONIC VIB TIME-MIN	1.0	1.0
SAMPLE WEIGHT-GRAM	11.7338 ±WET+	12.0013 ±WET+
TYPE OF SIEVES USED	ELECTRO FORM	ELECTRO FORM

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX L/N 148-61

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/06/72

NO OF SIEVE ANALYSES = 2
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 1

NO OF SUB-ANALYSES FOR ANALYSIS 2 = 1

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9820	78.1389
150	81.1320	81.5985
130	79.5881	80.0044
100	78.6753	79.8967
90	80.7312	81.6858
80	80.9975	81.6535
70	81.0250	81.7539
60	82.0603	83.2120
50	81.5650	82.1647
40	80.2388	81.1450
30	81.4303	82.0949
20	80.0300	80.4474
10	80.9374	81.3673
CENTRIFUGE		
1	43.9530	45.5178

ANALYSIS 2

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9800	78.1742
150	81.1310	81.5590
130	79.5851	80.0242
100	78.6738	79.9101
90	80.7296	81.7444
80	80.9947	81.6076
70	81.0236	81.7814
60	82.0578	83.2741
50	81.5627	82.1857
40	80.2376	81.1340
30	81.4289	82.1178
20	80.0285	80.4711
10	80.9339	81.3632
CENTRIFUGE		
1	43.9621	45.2673

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX L/N 148-61

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/06/72

SIEVE SIZE (MICRON)	ANALYSIS 1 WEIGHT RETAINED (GRAM)	ANALYSIS 1 WEIGHT % RETAINED	ANALYSIS 1 ACCUM. WEIGHT % RETAINED	ANALYSIS 2 WEIGHT RETAINED (GRAM)	ANALYSIS 2 WEIGHT % RETAINED	ANALYSIS 2 ACCUM. WEIGHT % RETAINED	COMBINED ANALYSIS DIFF IN WEIGHT %	COMBINED ANALYSIS COMBINED WT. RET. (GRAM)	COMBINED ANALYSIS WEIGHT % RETAINED	COMBINED ANALYSIS PERCENT COARSER THAN	COMBINED ANALYSIS PERCENT FINER THAN
180	0.3026	2.27	2.27	0.1936	1.95	1.95	0.327	0.4962	2.13	2.13	97.87
150	0.5873	4.41	6.69	0.4602	4.63	6.58	-0.215	1.0475	4.51	6.64	93.36
130	0.5252	3.95	10.64	0.4100	4.12	10.70	-0.177	0.9352	4.02	10.67	89.33
100	1.6289	12.24	22.88	1.2156	12.23	22.93	0.015	2.8445	12.24	22.90	77.10
90	1.3023	9.79	32.67	0.9772	9.83	32.76	-0.042	2.2795	9.81	32.71	67.29
80	0.8011	6.02	38.69	0.6927	6.97	39.73	-0.947	1.4938	6.43	39.14	60.86
70	0.9320	7.01	45.70	0.6423	6.46	46.19	0.544	1.5743	6.77	45.91	54.09
60	1.5249	11.46	57.16	1.1581	11.65	57.85	-0.189	2.6830	11.54	57.45	42.55
50	0.8976	6.75	63.91	0.6353	6.39	64.24	0.356	1.5329	6.60	64.05	35.95
40	1.2035	9.05	72.96	0.8892	8.95	73.18	0.101	2.0927	9.00	73.05	26.95
30	0.8499	6.39	79.34	0.6641	6.68	79.86	-0.293	1.5140	6.51	79.57	20.43
20	0.4732	3.56	82.90	0.3730	3.75	83.62	-0.196	0.8462	3.64	83.21	16.79
10	0.5264	3.96	86.86	0.4079	4.10	87.72	-0.147	0.9343	4.02	87.23	12.77
<10	1.7482	13.14	100.00	1.2205	12.28	100.00	0.862	2.9687	12.77	100.00	0.00
8				0.1208	1.22	88.94					
6				0.5130	5.16	94.10					
4				0.1971	1.98	96.08					
2				0.3717	3.74	99.82					
<2				0.0179	0.18	100.00					
ARITH MEAN	69.6118			70.7827				69.8209			
GEOM. MEAN	69.2763			70.4293				69.4832			

ELUDTANT USED	ISOBUTYL ACETATE	ISOBUTYL ACETATE
METHOD OF SIEVING	PANTEX AUTOWASH	PANTEX AUTOWASH
SIEVING TIME-MIN	20.0	20.0
ULTRASONIC VIB TIME-MIN	1.0	1.0
SAMPLE WEIGHT-GRAM	15.8000 >WET<	11.7151 >WET<
TYPE OF SIEVES USED	ELECTRO FORM	ELECTRO FORM

PARTICLE CHARACTERIZATION - SIEVE ANALYSIS

HERCULES SUPPLIED HMX
HMX L/N 148-61

CRYSTAL DENSITY : 1.9000 G/CM**3 DATE : 09/06/72

NO OF SIEVE ANALYSES = 2
NO OF SUB-ANALYSES FOR ANALYSIS 1 = 1

NO OF SUB-ANALYSES FOR ANALYSIS 2 = 2

ANALYSIS 1

SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9909	78.2935
150	81.1361	81.7234
130	79.5973	80.1225
100	78.6827	80.3116
90	80.7318	82.0391
80	81.0028	81.8039
70	81.0280	81.9600
60	82.0652	83.5901
50	81.5696	82.4672
40	80.2441	81.4476
30	81.4352	82.2851
20	80.0337	80.5059
10	80.9524	81.4788
CENTRIFUGE		
1	43.9385	45.6787

ANALYSIS 2

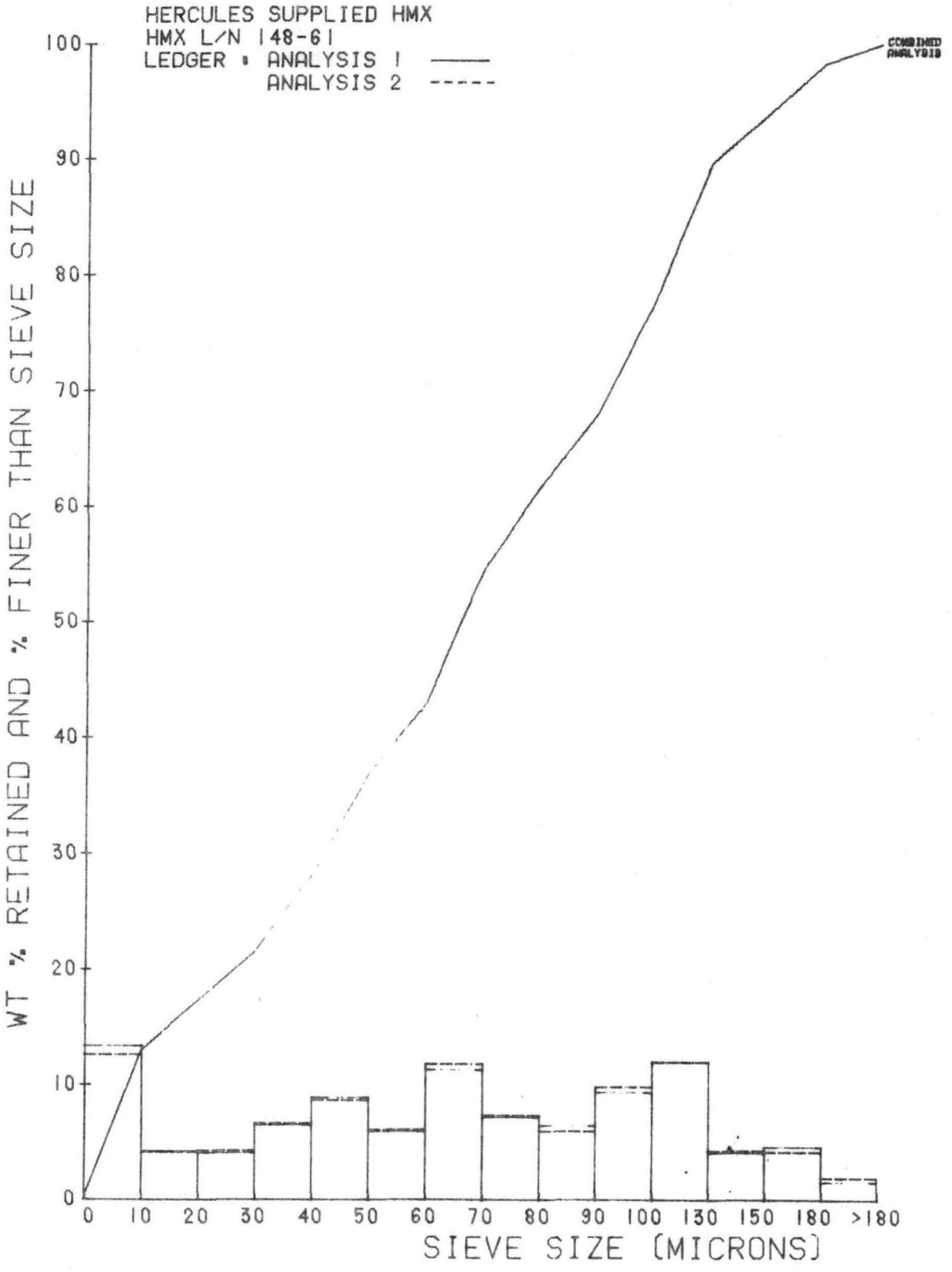
SIEVE SIZE (MICRON)	SIEVE WEIGHT (GRAM)	SIEVE + WEIGHT RETAINED(GRAM)
180	77.9836	78.1772
150	81.1312	81.5914
130	79.5898	79.9998
100	78.6758	79.8914
90	80.7283	81.7035
80	80.9983	81.6910
70	81.0241	81.6664
60	82.0625	83.2206
50	81.5682	82.2035
40	80.2386	81.1278
30	81.4308	82.0949
20	80.0300	80.4030
10	80.9398	81.3477
CENTRIFUGE		
1	43.9352	45.1557

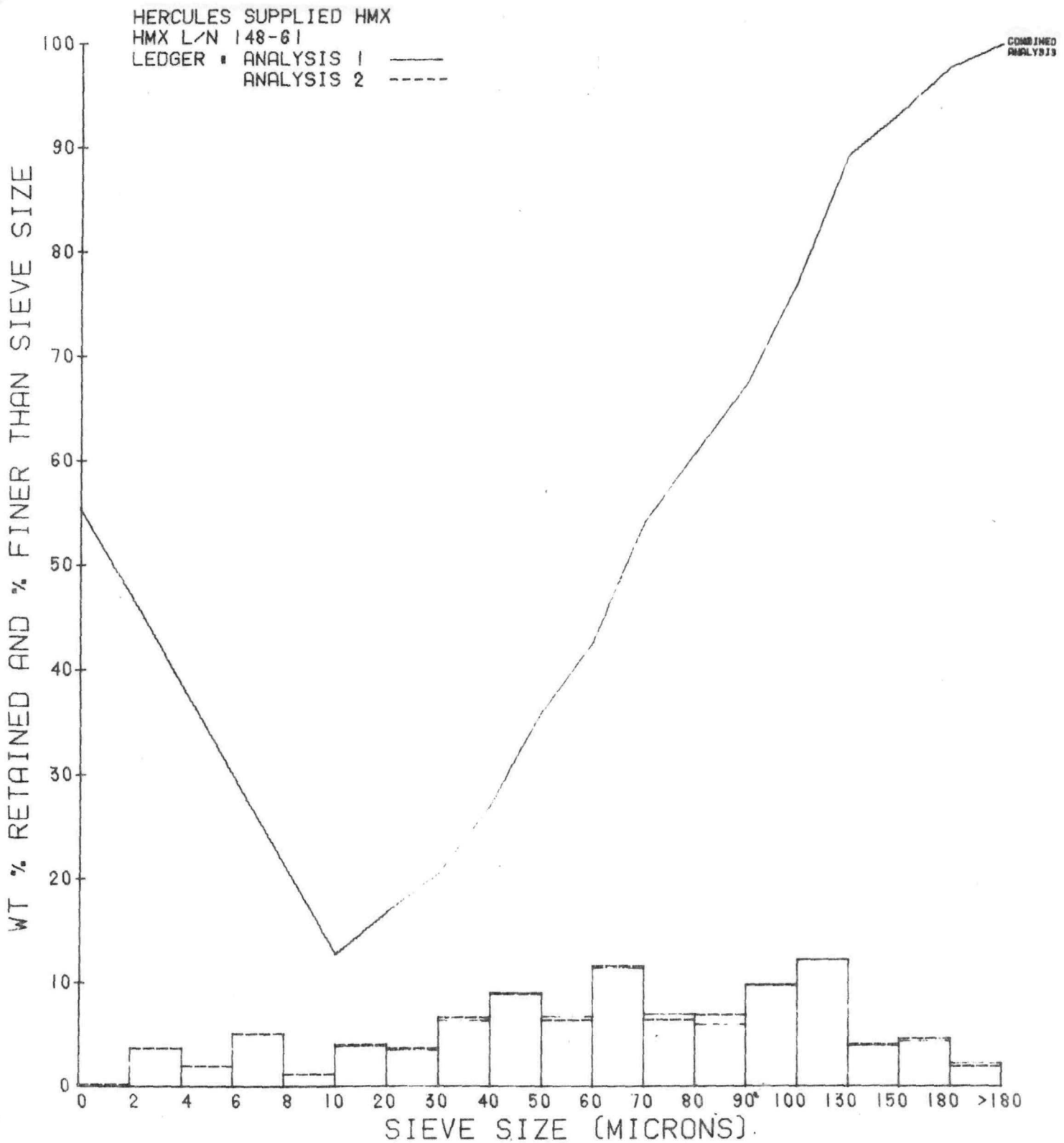
SIEVE SIZE
(MICRON)

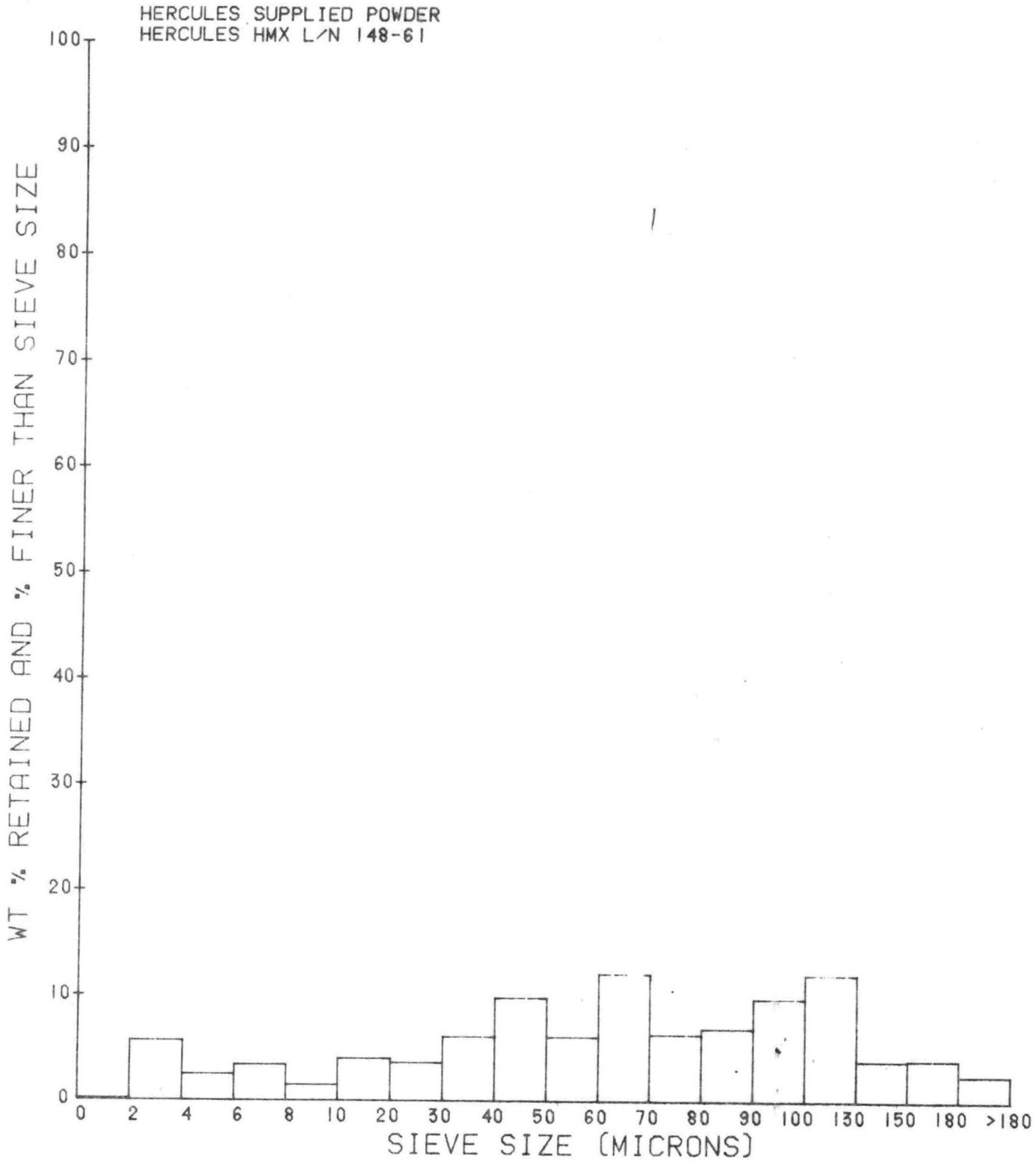
8	78,5805	78,5987
6	78,6622	78,7395
4	77,7873	77,8170
2	77,0282	77,0842

CENTRIFUGE

1	11,0475	11,0502


HERCULES SUPPLIED HMX
HMX L/N 148-61
LEDGER - ANALYSIS 1
ANALYSIS 2
WT % RETAINED AND % FINER THAN SIEVE SIZE
SIEVE SIZE (MICRONS)
0
10
20
30
40
50
60
70
80
90
100
130
150
180
>180


HERCULES SUPPLIED HMX
HMX L/N 148-61
LEDGER ▪ ANALYSIS 1
ANALYSIS 2
COMBINED ANALYSIS
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 2 4 6 8 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)


HERCULES SUPPLIED POWDER
HERCULES HMX L/N 148-61
WT % RETAINED AND % FINER THAN SIEVE SIZE
100
90
80
70
60
50
40
30
20
10
0
0 2 4 6 8 10 20 30 40 50 60 70 80 90 100 130 150 180 >180
SIEVE SIZE (MICRONS)

Two Eight Zero Four Six ERA;EDB;NTS
0220.F02 28046 R
(MHSMP--72-74) Particle size analysis of HMX.
Duncan, A.A. (Mason and Hanger-Silas Mason Co., Inc., Amarillo, TX (USA)). 27 Oct 1972. Contract Ey-76-C-04-0487. 55p. Dep. NTIS, MF A01.
Portions of document are illegible.

MN-45 P TIC EDB-450100;

FILE- TD0220.F02
28046 R TD122078 TD122178 03Uncl
07Duncan, A.A.
11Particle size analysis of HMX
15MHSMP--72-74
24Contract Ey-76-C-04-0487
3727 Oct 1972 39 55p. 43Dep. NTIS, MF A01
44Portions of document are illegible
50Other
51MN-45 52P 53ERA;EDB;NTS
54EDB-450100;
55TIC 56United States of America (USA) 57United States of America (USA)
70395 4000 71Mason and Hanger-Silas Mason Co., Inc., Amarillo, TX (USA)

Check DE: 43 AUTHORITY CHECK[Dep.].