

Johnson & Johnson

NEW BRUNSWICK, N. J. 08903

March 7, 1974

R. Schaffner, Ph.D.
Director, Office of Product Technology
Bureau of Foods
Food and Drug Administration
200 "C" Street
Washington, DC 20204

Dear Dr. Schaffner:

Thank you for your help in arranging a briefing session between Johnson & Johnson and the Commissioner. As a result of this session, we are continuing our cooperative efforts to help resolve the talc/asbestos question.

We are, therefore, submitting herewith the following information:

1) Estimation of Talc Dust Exposure for Infants

This report comprises measurements of dust levels achieved when a whole can of 9 oz. of JOHNSON'S Baby Powder is dusted and relating the exaggerated high dust condition to maximum use on babies (frequency and dusting time) elicited from two studies by A. Eden, M.D. The resulting exposure level is compared to talc TLV for miners.

2) A proof copy of a publication entitled, "The Detection of Chrysotile Asbestos at Low Levels in Talc by Differential Thermal Analysis" by John P. Schelz, Johnson & Johnson.

With respect to Item (1), we believe the infant exposure data is far in excess of real exposure data since it is based on dusting of a whole can of baby powder. However, it is being submitted for whatever value it may have in your investigation of infant exposure.

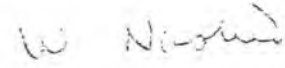
Dr. Schaffner

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March 7, 1974

We would like to consider this data (Item 1) as confidential and the Food and Drug Administration is not authorized to make it public without written permission from the company.

Very truly yours,
JOHNSON & JOHNSON


by: W. Nashed, Ph.D.
Director of Science Information

wn:ldh

Attachment

Johnson & Johnson

New Brunswick, N.J.

Subject: An Estimated Upper Limit for Talc Dust
Exposure of Infants Compared with the
OSHA Threshold Limit Value for Talc Miners

February 19, 1974

Dr. W. Nashed:

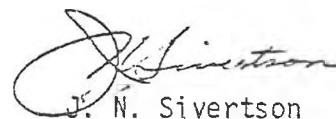
Upper limits for talc dust exposure for infants in a one week period were estimated on a particle-time basis from experimental data supplied by Dr. F. D. Pooley and Alvin N. Eden, M.D. The experimental values used to estimate an upper limit for talc exposure for infants were those which correspond to maximum exposure conditions. Whenever estimates were employed, conservative numbers were selected, that is, values which tended to increase the estimated exposure.

A second estimate was made which more closely approximates median exposure levels of infants to talc dust, but even this was based on conservative assumptions and probably represent an exposure level which is generally greater than normal. For example, all estimates were based on applying the talc directly to the diaper area from a container, which is the mode of application which creates the greatest concentration of talc dust. An alternate mode which produces substantially less dust is employed by many mothers who transfer talc from the container to their hand and gently stroke this powder onto the infant.

To provide a basis of comparison a particle-time exposure was computed for a talc miner in contact with the OSHA T.L.V. for talc of 20 mppcf for a 40 hour week.

This particle-time exposure value for a miner is at least 370 times the corresponding upper limit exposure value for an infant and is about 7840 times the exposure of an infant under more nearly median conditions.

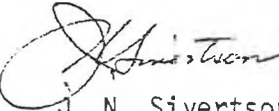
For ease of comparing results the exposure levels are presented in the attached table. A complete summary of the computations and assumptions are discussed in the attached report.


J. N. Sivertson

clc

Summary Table Comparing the Talc Dust Exposure Levels
for Talc Miners and Infants

<u>Type of Estimate</u>	<u>Exposure Levels</u> <u>mppcf-hrs per week</u>	<u>Ratio of Miner</u> <u>to Infant Exposure</u>
OSHA T.L.V. for Miners	800	---
Infant - Upper Limit Exposure	2.16	370
Infant - Median Exposure	0.102	7,840


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February 19, 1974

COMPARISON OF TALC DUST EXPOSURE

FOR

INFANTS AND TALC MINERS

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February 19, 1974

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V.	Summary of <u>Parameters Associated with Powdering a Baby as They Affect the Talc Cloud</u> Submitted by Dr. F. D. Pooley.

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COMPARISON OF TALC DUST EXPOSURE
FOR INFANTS AND TALC MINERS

Introduction:

In this report the exposure of infants to talc dust has been estimated from experimental work conducted by Doctors Pooley and Eden. This exposure is expressed in units of concentration-hours, that is, the product of the concentration in air and the number of hours in contact with this air. In this instance the concentration is expressed as million particles per cubic foot (mppcf) of air; thus, exposure is expressed in terms of mppcf-hours (or in some instances, mppcf-minutes). It is possible to express the OSHA Threshold Limit Value (T.L.V.) for talc miners on a similar basis in order to compare exposures.

The experimental results in the attached reports by Doctors Pooley and Eden exhibit considerable variability, and to illustrate the effect of this variability two different exposure estimates will be developed. The first estimate will be an upper limit for the exposure of infants to talc dust, and the second will establish an exposure level closer to median conditions.

On occasion it will be necessary to make certain assumptions if experimental data are either missing or incomplete. It will be clear from the discussions in the text that assumptions made affecting infant exposure are purposely made conservative (i.e. tend to make the exposure level high). Thus, all the results including the median exposure results for infants are probably greater than normal.

Estimation of an Upper Limit for Infant Exposure to Talc Dust:

The data on which all computations in this report are based may be found in the following four reports:

1. Report of Dusting Experiments Performed with Johnson & Johnson Baby Powder by Dr. F. D. Pooley of University College, Cardiff, February 10, 1972.
2. A clinical study conducted by Alvin N. Eden, M.D. to determine the methods by which baby powder was applied to infants by their mothers and the daily frequencies of application, submitted November 22, 1971.
3. A second clinical study conducted by Alvin N. Eden, M.D. to determine the number of seconds required for the application of baby powder to different areas of the infants and the weight of powder employed.
4. A summary of Parameters Associated with a Baby as They Affect the Talc Cloud by Dr. F. D. Pooley.

In report 1 above, Doctor Pooley simulated the application of talcum powder to the diaper area of an infant in a series of seven trials. In order to obtain sufficiently large dust clouds to sample effectively with a Mining Research Establishment (M.R.E.) sampler, he emptied a 9 ounce (255 grams) container of Johnson's Brand Baby Powder by shaking and squeezing in each of seven experiments. The length of time taken to empty each container ranged from 6.0 to 9.8 minutes (estimated by dividing the total

air volume collected in each experiment by the sampling rate of 2.5 liters per minute). The air was sampled from a position in space approximating the location of an infant's nose relative to the dusting area. In this series of tests he collected a total volume of 137.0 liters of air (total time = $137.0/2.5 = 54.8$ minutes) while dusting a total of 1785 grams (= 7×255) of powder. This corresponds to an average dusting rate of $1785/58.4 = 32.6$ grams per minute or $32.6/60 = 0.523$ grams per second. In contrast Doctor Eden found (Report 3 above) that the maximum dusting rate was 0.147 grams per second and the median rate, 0.060 grams per second. Thus, Doctor Pooley created dust $0.523/.147 = 3.56$ times faster than the maximum observed by Doctor Eden in actual use tests and $0.523/.060 = 8.72$ times faster than the median rate.

Since Doctor Pooley found 2.12 mppcf of talc dust in air at an accelerated dusting rate, an estimate of the talc dust concentration under median application rates is obtained by proportioning concentration to rate as follows:

$$\frac{2.12}{0.060} \div \frac{0.523}{0.523} = 0.243 \text{ mppcf}$$

Note: $(.060/.523) \times 100 = 11.5$ percent.

Report 2 contained data regarding the frequency of talc application and application times and Report 3 also contained data about application times. A daily frequency distribution was prepared from data in

Report 2. This distribution was based on applying powder directly from the canister to the diaper area, since this mode of use represents the type of application employed by 67 percent of the mothers and is the dustiest mode of application. Although data on the duration of talc applications in the two reports were similar, data from Report 3 was used to prepare a distribution of application times since the data recorded in the hospital was more precise. Only data pertaining to timing the direct application of talc to the diaper site was employed.

The two frequency distributions employed are as follows:

From Report 2		From Report 3	
Frequency of Use		Application Times	
Weighting Factor*	Daily Frequency of Use	Weighting Factor*	Time in Seconds
6	1	3	3
22	2	3	4
5	3	19	10m
6	4	11	15
8	5m	1	18
18	6	4	20
6	7	2	25
6	8		
1	9		
		Total: 43	
Total: 78			

m = median value

* Weighting factors are the number of times the data were reported in the study. In the table on the left the factors shown represent the original weighting factors multiplied by two to eliminate fractions.

After talc has been applied the major portion of the dust cloud settles very rapidly as shown by Doctor Pooley (See Report 4 above and Figure I). He found, for example, that about 2.1 percent of the talc particles remained in suspension 1.25 minutes after the beginning of a 10 second (= 0.17 minute) dusting experiment (See Table I). The data in the first two columns of Table I were transcribed from Doctor Pooley's summary dealing with 10 second dusting in the "room" (Report 4) or were estimated from his data. Estimates are indicated by asterisks. The "room" data were used, since the room under discussion was the same room Doctor Pooley employed to determine the dust concentrations in his talc dusting experiments (Report 1).

The data in the Column 3 of Table I represent the percentage of particles remaining in the air at the end of the times shown in column 1, and are computed from the data in column 2. These number percentages were then used to compute the talc dust concentrations shown in column 4. The numbers in column 4 are percentages of the 2.12 mppcf of air as determined by Doctor Pooley's talc dusting simulations (Report 1). Column 5 in Table 1 is the average concentration of talc dust during the time intervals indicated by the brackets.

Using the above data and the curve shown in Figure I an estimation of an upper limit for talc dust exposure of an infant may be made by employing the following additional information and assumptions:

1. The maximum time required for applying talc directly to an infant's body was reported by Doctor Eden (Report 3) as 25 seconds (0.42 minutes).
2. The maximum daily frequency for talc application to an infant was reported by Doctor Eden (Report 2) as 9 times.
3. Two different conditions and their associated time intervals are related to the exposure of infants to talc dust.

<u>Condition</u>	<u>Duration (Mins.)</u>
3.1 Direct application of talc	0.42
3.2 Period for dust settling	1.08

The 1.08 minutes is the difference between 1.25 minutes elapsed time from the start of dusting and the 0.17 minutes (10 seconds) of dusting described in Report 4 ($1.25 - .17 = 1.08$).

Table for Estimating an Upper Limit
For Infant Exposure to Talc Dust

<u>Condition</u>	<u>Duration Minutes</u>	<u>Talc Concentration mppcf*</u>	<u>Exposure mppcf-minutes</u>
1. Applying Talc	0.42	2.12	0.890
2. Dust Settles	1.08	1.08	<u>1.166</u>

Exposure per application: 2.056

Upper Limit for daily exposure $9 \times 2.056 = 18.50$ mppcf-Minutes

Upper Limit for Weekly Exposure

$18.50 \times 7/60 = \underline{2.16}$ mppcf-Hours

*From Column 5 in Table I.

Weekly Talc Dust Exposure of a Miner Working in Dust Concentrations
Corresponding to the OSHA Threshold Limit Value

In order to estimate a weekly exposure of a talc miner on an equivalent basis for purposes of comparison, the OSHA Threshold limit value (T.L.V.) of 20 mppcf is employed (Reference b). The total weekly equivalent of the T.L.V. exposure would be $20 \times 40 = 800$ mppcf-Hrs. and this number is 370 times greater than the upper limit for infant exposure.

It is worth noting that the factor of 370 does not take into consideration the differences in minute volumes (liters of air inhaled per minute) between an infant and a miner. According to reference (a) the maximum minute volume for an infant is 0.697 li. per minute, while for an adult male doing light work the average value is 28.6 li. per minute and, at rest, is 7.43. As a conservative estimate consider the miner to be doing light work 1/4 of the time; then his expected minute volume would be $.25(28.6) + .75(7.43) = 12.72$ li per minute. Thus, the miner would, on the average, breathe $12.72/.697 = 18.25$ times more air than the infant.

Estimation of An Exposure Level of Infants to Talc Dust
Which is Closer to Median Conditions

To estimate an exposure closer to median conditions the factors to be considered are:

1. The concentration of talc dust in the air during the talc application period is 0.243 mppcf as shown on page 3, and during the dust settling period, 0.124 mppcf. (11.5 percent of concentrations shown in Table I, Col. 5).

2. The median daily frequency of talc application is 5.
3. Two different conditions and their associated time intervals are related to the more nearly median exposure of infants to talc dust.

<u>Condition</u>	<u>Duration (Mins.)</u>
3.1 Direct application of talc	0.17
3.2 Period for dust settling	1.08

Table for Estimating Closer to the Median Exposure
of Infants to Talc Dust

<u>Condition</u>	<u>Duration</u> <u>Minutes</u>	<u>Talc Concentration</u> <u>mppcf*</u>	<u>Exposure</u> <u>mppcf-Minutes</u>
1. Applying Talc	0.17	0.243	0.0413
2. Dust Settles	1.08	0.124	<u>0.1339</u>

Exposure per application: 0.1752

Median daily exposure $5 \times 0.1752 = 0.876$ mppcf-minutes

Estimated Median Weekly Exposure

$$0.876 \times 7/60 = 0.102 \text{ mppcf-Hrs.}$$

* From Column 6 in Table I.

Ratio of equivalent T.L.V. for a miner to the above total weekly exposure is $800/.102 = \underline{7840}$.

Summary Table Comparing the Talc Dust Exposure Levels
for Talc Miners and Infants

<u>Type of Estimate</u>	<u>Exposure Levels</u> <u>mppcf-hrs per week</u>	<u>Ratio of Miner</u> <u>to Infant Exposure</u>
OSHA T.L.V. for Miners	800	---
Infant - Upper Limit Exposure	2.16	370
Infant - Median Exposure	0.102	7,840

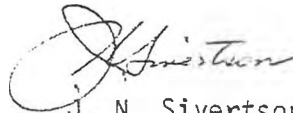

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Table I

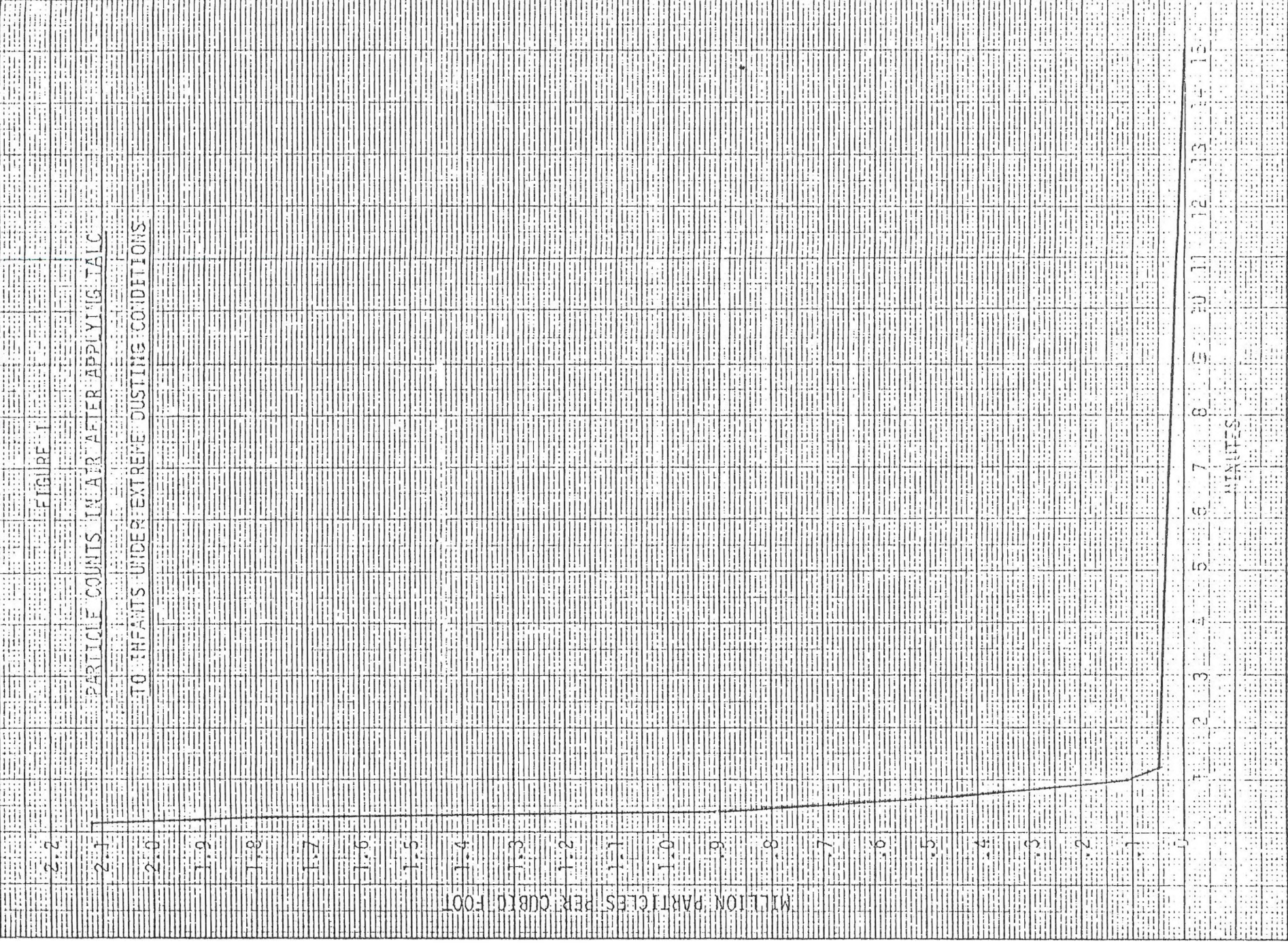
Col. 1	2	3	4	5	6
<u>Minutes After Starting Talc Application</u>	<u>Data from Pooley's Talc Dust Settling Experiment mppcf</u>	<u>Percent of Number Present at End of Dusting For 10 Secs (.17 Min.)</u>	<u>Particle Count Estimated From Pooley's Talc Application Studies mppcf</u>	<u>Estimated Count at Interval Midpoint mppcf</u>	<u>Estimated Count 11.5% of Col. 5 mppcf</u>
0.17	4.7*	100.0	2.12	2.12	.243
0.25	3.9	83.0	1.76	1.08	.124
0.50	1.72	36.6	0.78		
1.00	.24	5.1	0.11		
1.25	.1**	2.1	0.045		

* Estimated from original data: $3.9 - 3.1 = 0.8$
 $0.8 + 3.9 = 4.7$

** Doctor Pooley stated that no appreciable collection of particles was obtained after 75 seconds (1.25 Minutes). The concentration at 1.25 Minutes was estimated to be 0.1 mppcf.

- REFERENCES -

- (a) Biology Data Book, Federation of American Societies
for Experimental Biology, p. 220, 1964.
- (b) "Threshold Limit Values for Chemical Substances in
Workroom Air Adopted by ACGIH for 1973", p. 33.



Section II

REPORT BY F. D. POOLEY ON DUSTING EXPERIMENTS

PERFORMED WITH JOHNSON'S* BRAND BABY POWDER

* Trademark of JOHNSON & JOHNSON



TF 00 43

University College, Cardiff

Postal Address: University College, Newport Road, Cardiff CF2 1TA.
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From..... Dr. F.D. Pooley

Department of..... Mineral Exploitation

Report of Dusting Experiment Performed With Johnson and Johnson Baby Powder

This report contains the results obtained from an experimental dusting of an infant. The objective of the investigation was to determine the quantity and quality of the dust likely to be produced in the vicinity of an infant subjected to dusting with a container of Johnson and Johnson baby powder.

Experimental Procedure

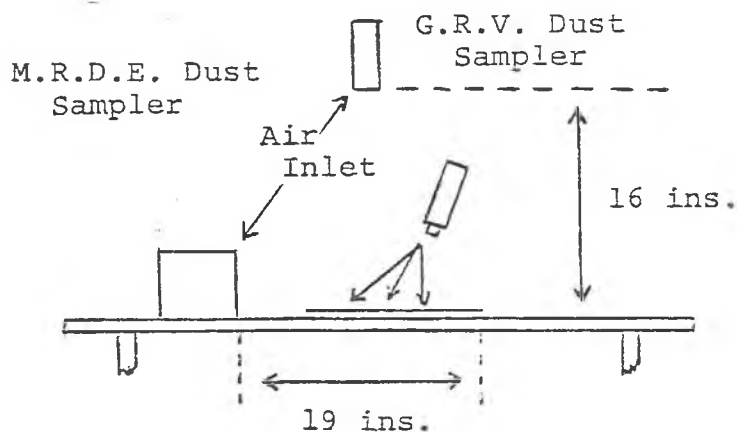
The quantity of dust produced in an actual dusting of an infant cannot be effectively measured with standard dust sampling equipment. This is due to the fact that the dusting period is relatively short being in the order of seconds and also because the amount of powder displaced from the container in this short period is insufficient to produce a dust cloud which can be effectively sampled. Simulation of the dusting operation was therefore performed in this investigation by continuously applying the whole of the contents of a container of powder to an area representative of an infant.

To sample the dust cloud generated in this operation and likely to be available for inhalation by an infant a gravimetric dust sampling instrument was placed with its sampling orifice in the approximate position of the infant's nose. A second dust sampling instrument was also placed in the position of the nose of the person applying the powder. The instrument employed at the infant's nose was an M.R.E. size selective gravimetric dust sampler with a continuous sampling rate of 2.5 litres/minute.

The second sampler was also a size selective gravimetric sampler of the cyclone type, sampling at a rate of 1.9 litres/minute. Both instruments have identical size selection characteristics and also retain the non-selected or oversize airborne particles for analysis.

The dust collected by the M.R.E. Sampler was deposited onto glass fibre filters while the dust collected in the second instrument (which shall be referred to in the rest of this report as the G.R.V.) was deposited on membrane filters of a cellulose construction.

A schematic diagram of the dusting arrangement adopted is given below:-



The powder was continuously shaken from a container from a height varying from 3-5 inches into a shallow tray with one inch side walls. The container was sometimes squeezed as well as being shaken and also inverted and tapped several times during the dusting operation to clear the outlet holes which tended to block.

The dusting operation was performed on a table in the centre of a room 12ft by 15ft in size with a ceiling height of approximately 15ft. Three individuals were used to shake the powder containers each being seated at the table on which the experiment was performed in a position suitable to perform an actual baby dusting operation.

Clean filters were weighed and inserted into the dust sampling instruments which were then placed in position on the table. The instruments were then switched on and a container of powder shaken continuously until empty onto the collecting tray. The instruments were then switched off and taken to a balance room where the filters were reweighed and the dust sampled obtained by weight difference. The room in which the dusting was performed was allowed to clear by opening all available windows and the one connecting door before repeating the dusting experiment.

Before proceeding with the dusting experiments background dust counts in the room were taken using both instruments and the following readings were obtained:-

M.R.E. Sampler:

Volume sampled 294.0 litres

Weight of dust collected on filter = 0.00015 grams.

Weight/litre = 0.0000005 grams.

G.R.V. Sampler:

Volume sampled 245 litres

Weight of dust collected on filter = 0.0001 grams.

Weight/litre = 0.0000004 grams.

The background count in the dusting room can be seen to be very low at between $4 - 5 \times 10^{-7}$ grams/litre of air.

Results:

The results obtained for dust concentrations during powdering simulation tests from both instruments are given in Table 1.

TABLE 1
M.R.E. Sampler (Positioned at infant's nose)

<u>Volume Sampled litres</u>	<u>Weight of Dust Sampled grams</u>	<u>Concentration per litre</u>
20.0	0.0002	0.00001
15.5	0.0001	0.0000065
24.5	0.00015	0.000006
23.5	0.00015	0.0000065
16.5	0.0003	0.000018
15.5	0.0001	0.0000065
21.5	0.0001	0.0000047
<u>Total:</u> 137.0	<u>0.0011</u>	

Average volume = 19.57 litres
 Average dust weight sampled = 0.000157 grs.
 Average dust concentration/litre = 0.000008 grms.
 Average dust concentration/cu metre = 0.008 grams.

The variation in the air volume sampled for each of the tests recorded in Table 1 is due to the different time taken by the three persons employed to shake the container of powder.

Results obtained from the sampling instrument placed above the dusting area are given in Table 2.

TABLE 2

G.R.V. Sampler (positioned 18 inches above dusting area)

<u>Volume Sampled litres</u>	<u>Weight of Dust Sampled grs</u>	<u>Concentration per litre</u>
16.1	0.00025	0.000015
12.0	0.00005	0.00004
12.6	0.00015	0.000012
18.5	0.00015	0.00005
15.5	0.00010	0.000065
15.0	0.00010	0.000067
15.0	0.00010	0.000067
<u>Total:</u> 104.7	<u>0.00090</u>	

Average volume = 15.0 litres
 Average dust weight sampled = 0.00012 grams
 Average dust concentration/litre = 0.000008 grms
 Average dust concentration/cu metre = 0.008 grams

Tables 1 and 2 represent the respirable fraction as selected by both machines. It can be seen that an identical airborne concentration was obtained. The actual size distribution of this material is given by Table 3, which represents five individual determinations of size distribution, three of which were obtained from material sampled by the M.R.E. sampler and two from the G.R.V. sampler. Dust was removed from the M.R.E. glass fibre filter by gently washing it with alcohol. The suspended dust was then sampled onto clean microscope slides and allowed to dry before sizing. The dust sampled by the G.R.V. instrument onto membrane filters was sized directly on the filter by making them transparent with 2-Ethoxyethanol. All size analyses were performed automatically using a Quantimet 720 image analysing device. Each set of results presented in Table 3 was produced sizing over 10,000 particles.

TABLE 3

Percentage distribution of particles by number
collected by the M.R.E. and G.R.V. samplers.

<u>Size Range</u> <u>Microns</u>	<u>M.R.E.</u> <u>Sampler</u>	<u>M.R.E.</u> <u>Sampler</u>	<u>M.R.E.</u> <u>Sampler</u>	<u>G.R.V.</u> <u>Sampler</u>	<u>G.R.V.</u> <u>Sampler</u>	<u>Av.</u> <u>Values</u>
<u>% number of particles within each range</u>						
0 -0.87	34.8%	37.0%	50.3%	35.1%	49.8%	41.4
0.87-1.74	12.0	13.0	17.85	8.8	14.1	13.2
1.74-2.61	15.5	15.85	12.35	9.5	12.4	13.1
2.61-3.48	12.6	12.5	7.9	11.0	8.5	10.5
3.48-5.22	14.4	13.65	7.3	17.9	9.3	12.5
5.22-6.96	6.6	5.0	2.6	9.9	3.5	5.5
6.96-17.4	4.2	3.2	1.8	7.5	2.1	3.7
	<u>100.1</u>	<u>100.2</u>	<u>100.1</u>	<u>99.7</u>	<u>99.7</u>	<u>99.9</u>

Both sampling instruments also collected an oversize or non respirable dust fraction. This oversize fraction was removed from each sampler after completion of all the dusting tests by flushing the elutriation system of each sampler with alcohol to remove the dust which in each case was then dried, weighed and sized. The results obtained from the two samplers are given below:

Non respirable fraction obtained from
the M.R.E. sampler

Weight of dust recovered = 0.065 grs.

Total amount of dust
laden air sampled = 193 litres

Concentration of non
respirable dust/
litre of air = 0.000337 grs.

Concentration of dust/
cu metre = 0.337 grs.

The size distribution of non respirable dust from the
M.R.E. sampler obtained using the Quantimet image analyser
is given in Table 4.

TABLE 4

Size Distribution of Non Respirable Dust Obtained
from the M.R.E. sampler

<u>Size Range</u> <u>Microns</u>	<u>Sample</u> <u>1</u>	<u>Sample</u> <u>2</u>	<u>Sample</u> <u>3</u>	<u>Sample</u> <u>4</u>	<u>Av.</u> <u>Values</u>
<u>% number of particles within each range</u>					
0-4	30.6%	25.0%	33.0%	28.9%	29.4%
4-8	23.4	17.4	18.2	17.4	19.1
8-12	15.1	13.4	8.8	9.7	11.7
12-16	9.9	11.0	6.7	7.8	8.9
16-20	6.9	9.2	5.9	7.2	7.2
20-30	9.5	13.3	12.0	13.5	12.2
30-60	4.5	10.1	13.8	14.1	10.6
above 60	0.1	0.6	1.6	1.4	0.9
					<u>100.0</u>

Non Respirable fraction obtained from
the G.R.V. sampler

Weight of dust recovered = 0.002 grs.

Total amount of dust
laden air sampled = 146 litres

Concentration of non
respirable dust/litre
of air = 0.0000137 grs.

Concentration of dust/
cu. metre = 0.0137 grs.

The size distribution of the non respirable dust from the G.R.V. sampler obtained using the Quantimet image analyser is given in Table 5.

TABLE 5
Size Distribution of Non Respirable Dust
obtained from the G.R.V. sampler

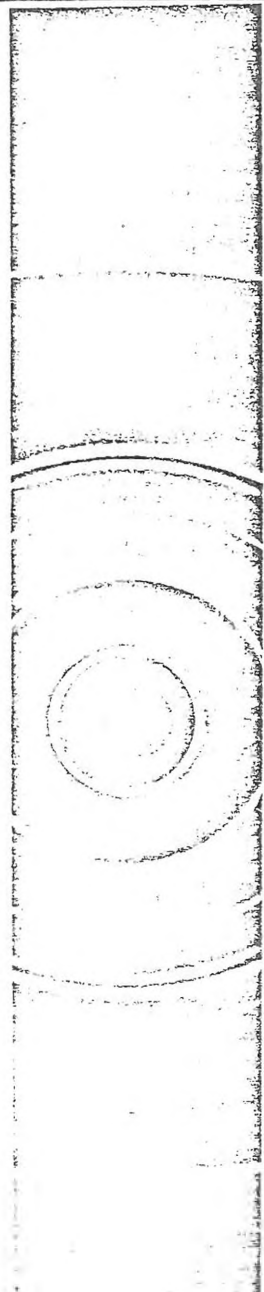
<u>Size Range</u> <u>Microns</u>	<u>Sample</u> <u>1</u>	<u>Sample</u> <u>2</u>	<u>Sample</u> <u>3</u>	<u>Sample</u> <u>4</u>	<u>AV:</u> <u>Values</u>
<u>% number of particles within each range</u>					
0-4	33.58%	31.7%	31.0%	31.6%	31.97%
4-8	27.38	31.05	29.5	28.9	29.21
8-12	17.18	16.10	16.35	17.2	16.71
12-16	9.43	9.01	9.25	10.2	9.48
16-20	5.20	4.90	5.67	4.9	5.14
20-30	5.36	5.16	5.83	5.24	5.40
30-60	1.82	2.22	2.53	1.92	2.12
above 60	0.05	0.04	0.06	0.04	0.05
					100.08

The results from the dusting experiment show that the concentration of respirable dust in the vicinity of the infant and parent's nose is the same. The non respirable fraction however, is larger in the vicinity of the infant's nose than the parent's. This decrease in larger particles with increase in height above the dusting area is to be expected as these larger particles have a tendency to settle very rapidly and are therefore only present in large concentrations close to the dusting surface. The respirable fraction, however, contains particles with a very much lower settling speed and these will tend to distribute themselves more readily and evenly in the vicinity of the dusting operation. The size distributions of the respirable fractions from the two samples are very similar.

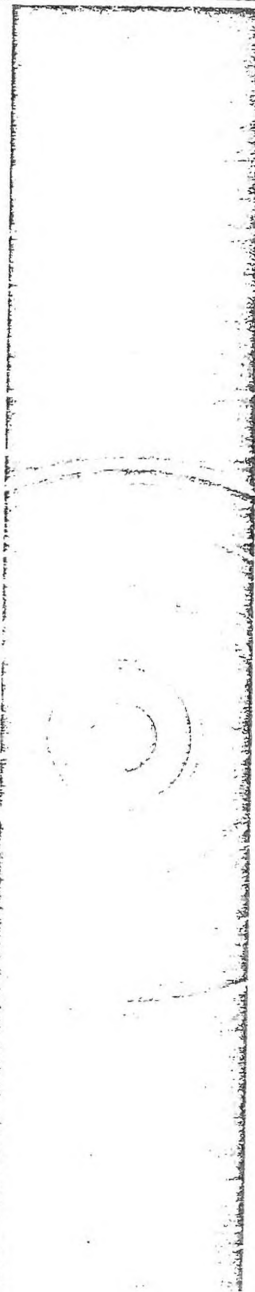
the size distribution of the non respirable fractions from the two samplers is very different, the G.R.V. non respirable size distribution being much finer than the M.R.E. non respirable fraction, which was collected closer to the dusting surface.

Samples of the respirable dust collected in both samplers were combined and subjected to x-ray powder diffraction and the photograph obtained compared with an x-ray powder photograph of a sample of dust from a container of baby powder. The two photographs are illustrated below. It can be seen that they are very similar. Measurement of the ring spacings show that the dust composition is identical with the material contained in the powder containers.

X-Ray Pattern
From Respirable
Dust Fraction



X-Ray Pattern
From Bulk Sample
of Baby Powder



Assuming a spherical dusting powder particle with a density of 2.88, the weights of single particles of a size corresponding to the mid point of range 'D' in Table 6 were then calculated as follows:-

$$e = \frac{\text{Mass}}{\text{Volume}}$$

$$\therefore 2.88 = \text{Mass} / \frac{4}{3} \cdot \pi \cdot r^3 \times 10^{-12}$$

r = particle radius in microns

$$\therefore \text{Mass} = 2.88 \times \frac{4}{3} \cdot \pi \cdot r^3 \times 10^{-12}$$

Mid Point of Range D microns	Mass of Single Particle grams
0.43	1.2×10^{-13} grs.
1.30	3.31×10^{-12} grs.
2.17	1.54×10^{-11} grs.
3.04	4.24×10^{-11} grs.
4.35	1.24×10^{-10} grs.
6.09	3.39×10^{-10} grs.
12.18	2.71×10^{-9} grs.

Using the mass of single particles and also the % contribution of each size fraction to the total mass, the number of particles contained in 0.0001 grams of respirable dust were computed as shown in Table 7.

In Table 7 the total dust weight 0.0001 grams has been divided up according to the % contribution of each size fraction to the total mass to give the actual weight of dust contained in each size fraction (B). This dust weight has then been divided by the weight of a single particle of mid point size in each range (C) to give the number of particles in each range ($\frac{B}{C}$).

TABLE 7

<u>Size Range Microns</u>	<u>B Mass of Dust in Size Range grams</u>	<u>C Weight of Single Particles in Range</u>	<u>B/C Number of Particles in Range</u>
0-0.87	$\frac{0.0001}{100} \times 0.035$	1.2×10^{-13} grs.	29.20×10^4
0.87-1.74	$\frac{0.0001}{100} \times 0.38$	3.31×10^{-12} grs.	11.46×10^4
1.74-2.61	$\frac{0.0001}{100} \times 1.42$	1.54×10^{-11} grs.	9.23×10^4
2.61-3.48	$\frac{0.0001}{100} \times 3.13$	4.24×10^{-11} grs.	7.38×10^4
3.48-5.22	$\frac{0.0001}{100} \times 10.96$	1.24×10^{-10} grs.	8.85×10^4
5.22-6.96	$\frac{0.0001}{100} \times 13.03$	3.39×10^{-10} grs.	3.85×10^4
6.96-17.4	$\frac{0.0001}{100} \times 71.3$	2.71×10^{-9} grs.	2.63×10^4
Total No. of Particles =			<u>72.60×10^4</u>

Assuming a spherical particle and a density of 2.88 it can be seen that a calculated figure of 726,000 particles is obtained for a weight of dust equal to 0.0001 grs. The average number of particles obtained on the G.R.V. membrane filters is given in Table 8.

TABLE 8

<u>Particle Number</u>	<u>Total Weight Gross</u>	<u>Number of Particles per 0.0001 grs.</u>
734,000	0.00015 grs.	490,000
544,000	0.0001 grs.	544,000
472,000	0.0001 grs.	472,000
524,000	0.0001 grs.	524,000
Average Value =		<u>507,500</u>

The particle numbers in the last column of Table 8 compare favourably with a computed number of 726,000 per 0.0001 grs. remembering that a spherical particle was assumed for calculation purposes.

The numbers of respirable particles per cubic metre obtained by converting the gravimetric result, i.e. 0.008 grs/cu metre, is as follows:-

Number calculated using the computed ^{580,}
726,000 particles/0.001 grs. = 58,000,000/cu metre ^{501 gr}

Number calculated using the value
obtained by particle counting
507,5000/0.0001 grs. = 40,600,000/cu metre

A similar calculation was performed to convert the gravimetric weight of non respirable dust collected in the M.R.E. and G.R.V. instruments. The results are as follows:-

Number of non Respirable particles/
cu metre obtained in the M.R.E.
sampler ³³⁷ = 16.96 x 10⁶ ^{72 X}

Number of Non Respirable particles/
cu metre obtained in the G.R.V.
sampler = 2.55 x 10⁶

(The calculations from which these two figures were produced are contained in the Appendices).

The total number of particles per cubic metre calculated using a spherical particle and an S.G. of 2.88 for the M.R.E. sampler which approximates to the infant's nose, is as follows:-

58.0 x 10⁶ = respirable number
16.96 x 10⁶ = non respirable number
Total = 74.96 x 10⁶ particles/cu. metre.
= 2.12 x 10⁶ particles/cu. ft.

Number of particles per cubic metre calculated as above for the G. R.V. sampler approximating to the parent's nose is as follows:-

58.0 x 10⁶ = respirable number
2.55 x 10⁶ = non respirable number
Total = 60.55 x 10⁶ particles/cu. metre
= 1.7 x 10⁶ particles/cu. ft.

Both of these figures are peak concentrations obtained while applying dusting powder.

CONCLUSIONS

The dusting experiments show that the dust concentrations produced in the vicinity of an infant and a parent are several times lower than the recommended levels of 20,000,000 particles per cubic foot.

The model of a spherical particle with a density of 2.88 used to compute particle numbers can be assumed to be a fair one. It can be seen from the calculated and counted numbers of particles obtained on several filters from the G.R.V. sampler that the model produces particle numbers approximately 30% higher than those measured with the Quantimet 720 image analyser. This difference should therefore be considered when examining the final particle number concentrations produced. The quality of the dust material produced during dusting corresponds to the material contained in the powder containers, as illustrated by the X-Ray results.

APPENDIX 1

Calculation of Particle Number Concentrations from Mass Data of the Non Respirable Dust Collected by the M.R.E. Sampler.

The size distribution of the non respirable dust collected by the M.R.E. Sampler is given in Table 4. For calculation purposes, those particles above 60 microns are considered to be aggregates composed of particles with a size distribution the same as that of the minus 60 micron material. By considering the plus 60 micron particles to be aggregates this effectively increases the weight of the other size fractions by an amount proportional to their number concentration and size.

The calculation of particle number has been performed in an identical manner to the example presented earlier. Table 9 contains the relevant data used to calculate the % contribution of each size fraction to the mass fraction.

TABLE 9

<u>Size Range Microns</u>	<u>Mid Point of Range</u>	<u>% Number in Range</u>	<u>Weighting (Diameter³)</u>	<u>% Contribution to mass Fraction</u>
0-4	2	29.4%	8	0.0178%
4-8	6	19.1	216	0.310
8-12	10	11.7	1000	0.887
12-16	14	8.9	2744	1.850
16-20	18	7.2	5832	3.180
20-30	25	12.2	15625	14.470
30-60	45	11.5	91125	79.40
				100.1148

Assuming spherical particles with a density of 2.88, the weights of single particles corresponding to the mid point of range in Table 9 are given in Table 10.

TABLE 10

<u>Mid Point of Range Microns</u>	<u>Weight of Single Particle in grams</u>
2	1.2×10^{-11} grs.
6	3.26×10^{-10} grs.
10	1.51×10^{-9} grs.
14	4.14×10^{-9} grs.
18	8.80×10^{-9} grs.
25	2.35×10^{-8} grs.
45	1.37×10^{-7} grs.

Using the weight of single particles and also the % contribution of each size fraction to the total mass, the number of particles obtained in a concentration of 0.337 grams per metre of non respirable dust, collected by the M.R.E. sampler, is given in Table 11.

TABLE 11

<u>Size Range Microns</u>	<u>Mass of dust in size range grams</u>	<u>Number of Particles in range</u>
0-4	$\frac{0.337}{100} \times 0.0178 = 0.0000604$ grs.	5.03×10^6
4-8	$\frac{0.337}{100} \times 0.887 = 0.001045$ grs.	3.21×10^6
8-12	$\frac{0.337}{100} \times 0.887 = 0.002984$ grs.	1.98×10^6
12-16	$\frac{0.337}{100} \times 1.85 = 0.00623$ grs.	1.51×10^6
16-20	$\frac{0.337}{100} \times 3.18 = 0.01070$ grs.	1.21×10^6
20-30	$\frac{0.337}{100} \times 14.47 = 0.04860$ grs.	2.07×10^6
30-60	$\frac{0.337}{100} \times 79.40 = 0.26630$ grs.	1.95×10^6
		16.96×10^6

Total number/cu. metre = 16.96×10^6
 Number/cu. ft. = 4.8×10^5

APPENDIX 2

Calculation of Particle Number Concentrations from Mass Data of the Non Respirable Dust collected by the G.R.V. Sampler.

The relevant calculations for the particle number are contained in Tables 12 and 13. Again an identical calculation procedure has been adopted to produce particle numbers in each size range. Also the plus 60 micron material has been assumed as aggregates for calculation purposes.

TABLE 12

<u>Size Range</u> <u>Microns</u>	<u>Mid Point</u> <u>of Range</u>	<u>% number</u> <u>in Range</u>	<u>Weighting</u> <u>(diameter³)</u>	<u>% Contribution</u> <u>to Mass Fraction</u>
0-4	2	31.97	8	0.0717
4-8	6	29.21	216	1.765
8-12	10	16.71	1000	4.680
12-16	14	9.94	2744	7.310
16-20	18	5.14	5832	8.410
20-30	25	5.40	15625	23.650
30-60	45	2.12	91125	54.100
				99.9867

The weight of single particles of mid point of range is the same as that contained in Table 10.

TABLE 13

Mass of dust and number of particles in each size range
contained in a concentration of 0.0137 grams of dust/
cu. metre as sampled by the G.R.V. sampler

<u>Size Range Microns</u>	<u>Mass of dust in Size Range-grams</u>	<u>Number of Particles in Range</u>
0-4	$\frac{0.0137}{100} \times 0.0717 = 0.00000983$ grs.	8.19×10^5
4-8	$\frac{0.0137}{100} \times 1.765 = 0.000242$ grs.	7.42×10^5
8-12	$\frac{0.0137}{100} \times 4.68 = 0.00064$ grs.	4.24×10^5
12-16	$\frac{0.0137}{100} \times 7.31 = 0.001001$ grs.	2.42×10^5
16-20	$\frac{0.0137}{100} \times 8.41 = 0.001151$ grs.	1.31×10^5
20-30	$\frac{0.0137}{100} \times 23.65 = 0.00324$ grs.	1.38×10^5
30-60	$\frac{0.0137}{100} \times 54.10 = 0.0074$ grs.	0.54×10^5
		25.50×10^5

Number of particles / cu. metre = 2.55×10^6

Number / cu. ft. = 7.23×10^4



F.D. POOLEY

10.2.72.

Conversion of Gravimetric Data to Number Concentrations

As recommended dust levels with Talc are quoted in particle numbers per unit volume of air, an attempt has been made to convert the weight figures into particle numbers. Several of the membrane filters used to collect dust in the G.R.V. sampler were scanned automatically with the Quantimet 720 image analyser and the number of particles per unit area of filter obtained. This number per unit area was then multiplied by the total filter surface to give total number of particles per filter. A comparison between the number of particles counted on each filter and the number calculated from the weight of dust on each filter could then be made to test the feasibility of converting mass of dust to numbers of particles.

The average size distribution of respirable dust collected by the G.R.V. instrument has been given in Table 3. Using this data and applying a weighting factor for the effect of particle size on the mass of a single dust particle, the % contribution of each size fraction to the total mass of dust collected was derived.

The last column in Table 6 represents the percentage contribution of each of the size fractions to the total mass of a dust sample with a size distribution as given under column A, which is the average size distribution of the sampled respirable fraction as determined from the M.R.E. and G.R.V. samplers and given in Table 3.

TABLE 6

Mass is related to size by the cubic power i.e.

$$\text{Mass} = (\text{density}) \left(\frac{4}{3} \cdot \pi \cdot \left(\frac{D}{2} \right)^3 \right) = \text{constant} \times D^3$$

<u>Size Range</u> <u>Microns</u>	<u>D</u> <u>Mid Point</u> <u>of Range</u>	<u>A</u> <u>% number</u> <u>in Range</u>	<u>D³</u> <u>Weighting</u> <u>(diameter)³</u>	$\frac{A \times D^3}{\Sigma(A \times D^3)}$ <u>% Contribution</u> <u>to Mass Fraction</u>
0-0.87	0.43	41.4%	.0795	0.035%
0.87-1.74	1.30	13.2	2.200	0.38
1.74-2.61	2.17	13.1	10.200	1.42
2.61-3.48	3.04	10.5	28.00	3.13
3.48-5.22	4.35	12.5	82.30	10.96
5.22-6.96	6.09	5.5	226.00	13.03
6.96-17.4	12.18	3.7	1810.00	71.30
				100.255

$$\Sigma A \times D^3 = 9401.99$$