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# Filter Pack Technique for Classifying Radioactive Aerosols by Particle Size

## Part 1 – Preliminary Report and Evaluation

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*Chemistry Division*

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Study of the efficiency of filters for the retention of natural airborne radioactive aerosols has shown that the particles with which the radioactivity of the short-lived radon daughters is associated have greater ability to penetrate the various filter media than has the fission product debris in the atmosphere; therefore the former is associated with aerosols of smaller size. A preliminary evaluation of the techniques of employing packs of filters of different retentivity characteristics to determine the particle size and/or particle size distribution of radioactive aerosols has been made which indicates the feasibility of the method. It is recommended that a series of measurements be undertaken to determine the relative particle size distribution of RaB+C as a function of time, season and weather, and the size distribution of fission products as a function of the above parameters and the source of the debris.

### INTRODUCTION

In 1950 a brief study was made of the technique of drawing air containing nuclear fission debris successively through filters of different retentivity characteristics as a means of determining the relationship of radioactivity to particle size. This method was employed at a number of field sites set up around the Eniwetok-Bikini area during the Greenhouse nuclear test series in the spring of 1951 to study the relationship of radioactivity to particle size but primarily to determine the extent of isotopic fractionation of debris within the various size ranges of particles collected. Other collections made at NRL on filters and screens also demonstrated the fractionation of radioactivity with particle size or collection method (1,2). This early work was carried out by a joint group composed of members of the Electron Optics Branch of the Optics Division and of the High Polymers Branch (now Physical Chemistry Branch) of the Chemistry Division. It relied heavily on the past experience of personnel of the Protective Chemistry Branch in the area of air filtration.

The present group at NRL, which has continued an active research program in atmospheric radioactivity, has had its interest rekindled in the problem of the relationship of radioactivity to particle

size, as the result of an extensive evaluation of filter media now in progress (3). Day-to-day differences were noted in the measured retentivity of fission products and radon daughter products (RaB+C) which could only be explained by differences in the size of the particles with which the radioactivity was associated. As a consequence, a number of filter pack collections employing filters of quite different retentivities for small particles have been made which have indicated both the reproducibility of the method and the fact that the relative amount of radioactivity associated with a particular size fraction varies with time.

The present report is preliminary in nature and is intended to describe the method and to document some of the recent measurements that have been made. It also points out a course for future research in this area.

### EXPERIMENTAL PROCEDURES

#### Method

In the filter pack technique, air is drawn successively through two or more filters superimposed upon one another so that equal volumes of air pass through equivalent areas of each filter, after which, on a suitable time schedule, the radioactivity of the various filters is assayed and compared. The schematic of a three-filter system in a typical filter holder is shown in Fig. 1.

NRL Problem A02-13; Project RR 004-02-42-5151. This is an interim report; work on this problem is continuing.

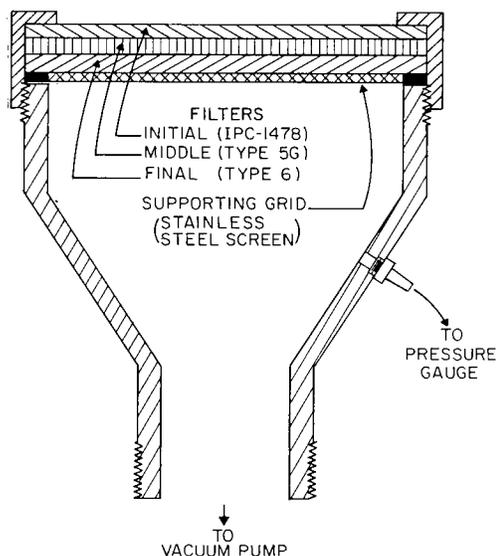


Fig. 1 - Schematic of a filter holder with a three-filter pack

### Filter Selection

The efficiency of a filter toward retention of particles of a given size is a function both of the filter composition and the linear velocity of air through the filter (usually considered as the average air velocity normal to the filter surface). For the successful application of this multiple filter technique, it is necessary to have filters whose retentivities for various size aerosols vary widely at some given flow rate. Among other factors to be considered in the selection of filter media for this purpose are resistance to airflow (which determines the power required for a collection of a given size), the effect of dust loading on flow rate, the uniformity and reproducibility of filters, and, of course, filter availability. The current program of filter evaluation provided many of the needed answers.

The basic filter media selected for use in this study were IPC-1478 paper (Institute of Paper Chemistry) as the initial or poorest filter, Type 5G paper (Hollingsworth and Vose) as the middle filter of intermediate retentivity, and Army Chemical Corps Type 6 paper (Navy N-15) as the final or "ultimate" filter. These media are of quite different physical characteristics and compositions but all consist of mats of fibers laid down by paper-making techniques. They are composed of, respec-

tively, cellulose, cellulose plus glass fibers, and cellulose plus asbestos fibers. In the preliminary study both three-filter and four-filter packs (the latter composed of IPC filters in both the topmost and second positions) were evaluated for possible utilization in this program; a few packs containing as many as six filters of the above types in various arrangements were also investigated.

Measured retentivities of these filters toward airborne radioactive aerosols are presented in Table 1; these values were obtained through use of a two-filter system employing Type 6 filters in the backup position. The penetration characteristics of IPC-1478, Type 5 (specifications identical to those of Type 5G) and Type 6 filters for  $H_2SO_4$  particles (density 1.8 g/cc) at several air velocities are given in Table 2.

### Equipment Selection

One characteristic of air filters is that they tend to become more efficient in removing particles from an air stream as the velocity of flow (linear velocity) is increased. This is a result of the impaction process being the dominant removal mechanism for particles in the size ranges of interest. Consequently, at the highest velocities available the various filter media lose their ability to discriminate effectively against particles of different size. However, the extremely low flow rates which give the best size discrimination do not permit collection of a statistically significant quantity of material in a reasonable sampling period. It is therefore necessary to reach a compromise between these two requirements.

An example of the equipment selected for this program is shown in Fig. 2. The air sampling system has a capacity of about 18 cubic feet per minute with a three-filter or four-filter pack of 4-inch-diameter filters in position. The resulting linear velocity is about 285 feet per minute (fpm). In spite of variations in the filter media and with the dust loading of the filters, the average linear velocity during all collections has remained in the range 260 to 290 fpm. These differences in flow would not be expected to alter significantly the retentivity characteristics of the filter media.

### Radioactive Aerosols

A number of different radioactive materials are normally in the atmosphere near ground level and

TABLE 1  
Measured Retentivities of IPC-1478, Type 5G, and Type 6 Filters  
Toward Airborne Radioactive Particulate Matter\*

Filter	Sampling Date	Weather	Unit A		Unit B		Unit C	
			Flow (ft/min)	Retention (%)	Flow (ft/min)	Retention (%)	Flow (ft/min)	Retention (%)
RaB+C (Natural Activity)								
IPC-1478	10-22-62	Clear	122	8.8±0.9	297	13.1±0.6	666	21.9±0.3
	3- 1-63	Cloudy	121	6.7±1.0	304	10.6±0.5	734	24.1±0.4
Type 5G	2-20-63	Clear	121	59.6±1.4	296	64.6±0.6	673	74.0±0.4
	3- 1-63	Cloudy	121	63.6±1.7	288	69.9±0.8	677	81.1±0.4
Type 6	10- 1-62	Fog	114	100.1±0.3	—	—	458	100.0±0.1
	3- 8-63	Clear	114	101.3±1.4	236	99.9±0.6	510	100.1±0.3
Fission Products								
IPC-1478	8/31-9/4/62	Clear	90†	33.9±0.3	301	56.1±0.2	715	71.3±0.2
	9/4-5/62	Cloudy	97†	44.9±0.6	298	59.9±0.5	736	81.7±0.2
	10/22-24/62	Clear	129	62.4±0.2	292	68.2±0.2	678	76.1±0.2
Type 5G	9/24-25/62	Cloudy	120	90.8±0.3	282	96.2±0.1	632	99.2±0.1
	10/26-30/62	—	119	90.7±0.1	281	97.3±0.1	605	99.0±0.1
	11/21-23/62	Rain	121	85.4±0.3	282	92.9±0.1	633	98.1±0.1
Type 6	6/27-29/62	Clear	87†	100.2±0.4	238	100.1±0.1	560	99.6±0.1
	10/12-15/62	Cloudy	113	99.9±0.1	228	100.0±0.1	400	100.0±0.1
	10/31-11/2/62	—	114	100.1±0.3	250	100.1±0.1	599	100.0±0.1

\*Compared with activity on Type 6 backup filter.

†Different filter unit used.

are suitable for the evaluation of filter characteristics or, conversely, are susceptible to particle size differentiation by the above procedure. These include radium B (plus RaC) and thorium B (plus ThC), which are short-lived solid daughter products of the gaseous natural radioisotopes radon and thoron; radium D ( $Pb^{210}$ ), a solid long-lived descendent of radon; and fission products from nuclear explosions. In this preliminary evaluation of the method, RaB+C and gross fission products have been studied; as is apparent in Table 1 and as will be shown again later, these radioactive materials differ markedly in regard to the size of the particles with which they are associated.

In order to determine the fission product content of the air filters, long collections (24 to 96 hours) were made, after which the filters were separated, put into envelopes, and allowed to decay for 7 to 14 days before counting. This delay

permitted removal of the natural radioisotopes RaB and ThB (26.8-minute and 10.6-hour half-lives, respectively) by the radioactive decay process. The filters were then counted for  $\beta$  activity in succession on the same counter using sufficiently long counting times (1 to 24 hours) to give reasonable counting accuracy. Radioactive decay during this counting period was negligible and the relative counting rates did not need correction for decay or other variables. End-window GM tubes (2-inch diameter) and conventional  $\beta$ -counting techniques were employed.

Radon-daughter products with their short effective half-lives were collected through a short sampling period (about 30 minutes), during which time approximately 50% of the equilibrium value of this radioactive material was collected on the filter pack. For such short sampling periods the collection of fission products and thorium decay

TABLE 2  
Filtration Characteristics of IPC-1478, Type 5, and Type 6 Filter Papers Toward H<sub>2</sub>SO<sub>4</sub> Aerosols\*

Particle Size ( $\mu$ )	Penetration at various face velocities (%)											
	14 fpm	22 fpm	28 fpm	35 fpm	52 fpm	70 fpm	106 fpm	142 fpm	212 fpm	280 fpm	420 fpm	560 fpm
IPC-1478 filter												
0.3	—	—	95	93	92	92	91	88	89	86	74	57
0.6	—	—	89	90	88	87	88	84	81	69	43	20
0.8	—	—	95	92	90	82	86	80	71	58	23	7
1.0	—	—	88	88	88	82	75	56	33	14	4	2
Type 5 filter												
0.3	25	25	24	23	22	20	18	15	12	8	4.7	2.1
0.6	19	19	19	20	19	15	10	6	3.9	1.6	0.26	0.10
0.8	18	17	16	15	12	8	5	3	1.4	0.4	0.11	0.03
1.0	11	8.5	6.5	7	4	2	1	0.9	0.5	0.3	0.02	0.002
1.2	8	6	5.5	5.0	2.0	1	0.6	0.1	0.02	0.000	0.000	0.000
Type 6 filter												
0.3	0.011	0.014	0.014	0.024	0.014	0.008	0.004	0.002	0.000	0.000	0.000	0.000
0.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

\*Unpublished data, Wendell L. Anderson, Protective Chemistry Branch, Chemistry Division, NRL.

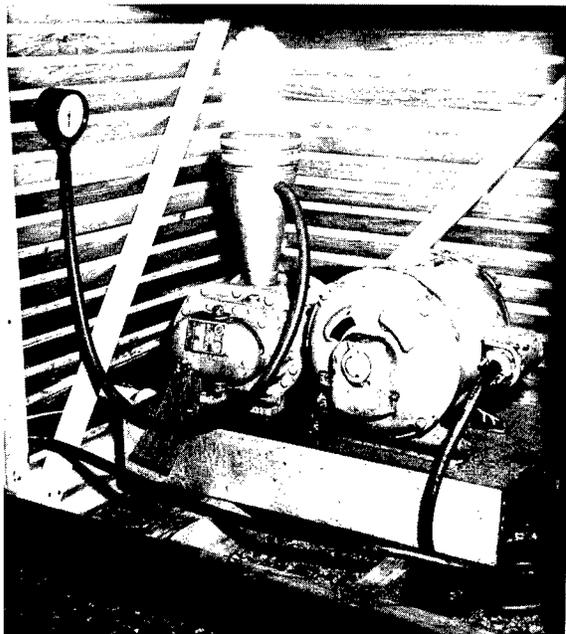


Fig. 2 - Air filter unit

products could be ignored (at least as a first approximation). Due to the short lifetime of this material, it is not practical to employ successive counting periods. Counting, therefore, has been done simultaneously on three or four  $\beta$ -counting units which had been intercalibrated with a fission product mixture of several months age and checked by intercomparisons with several RaB+C collections. This latter procedure requires the extrapolation of activity concentrations to a common time due to significant decay during the measuring process and is inherently less accurate; it does, however, compare the counter response to  $\beta$ -activity of the correct energy distribution. Counting times of 45 minutes have generally been employed.

## RESULTS AND DISCUSSION

Some of the recent data collected with filter packs is presented in Tables 3 to 6. The errors indicated are the standard deviations based solely on the statistical errors in counting and were calculated from the following relations:

$$\sigma_i = \sqrt{N_i} / N_i$$

where  $\sigma_i$  is the error of an individual count and  $N_i$  is the total accumulated count,

$$\sigma_t = \sqrt{\sigma_1^2 + \sigma_2^2 + \dots + \sigma_i^2}$$

where  $\sigma_t$  is the total error of the sum of a series of individual counts, and

$$\frac{C_i \pm \sigma_i}{C_t \pm \sigma_t} = \frac{C_i}{C_t} \pm \frac{1}{C_t} \sqrt{(C_i \sigma_i / C_t)^2 + \sigma_i^2}$$

where  $C_i$  and  $C_t$  are the average counting rates of an individual measurement and the sum of the measurements, respectively.

The effect of the air velocity through the filter (actually the face velocity or velocity of the air normal to the filter surface) on the distribution of airborne fission products on the various filters making up the pack (IPC-1478, Type 5G, Type 6) is shown in Table 3. It is evident that greater penetration and greater particle size discrimination is

achieved at the lower velocities. The reproducibility and precision of this technique is indicated in Table 4, where the results of duplicate collections are shown.

Other collections have indicated that even the least effective filter (IPC-1478) is able to retain a measurable fraction of the small particles. From a study of collections of RaB+C activity made on multiple packs of IPC filters, and also through collections by an IPC filter of fission product activity which has passed through a Type 5G filter, in both cases with a backup Type 6 filter, a limiting penetration of 95 to 96% seems to be approached. It is considered likely that a similar but greater effect is obtained with Type 5G filters. Some of this information is presented in Table 5. It has been obtained with a view to its employment in an extrapolation of curves of retentivity vs particle size to smaller particle sizes.

At present there is no technique for extrapolating available information on the retentivities of particles of 0.3  $\mu$  diameter and larger to particles of smaller diameter or composed of heavier materials than DOP (dioctyl phthalate, 0.98 g/ml) or  $H_2SO_4$  (1.8 g/ml). However, to subject the data

TABLE 3  
Effect of Air Velocity (Face Velocity) on the Distribution of  
Fission Product Radioactivity in a Three-Filter System

Collection Dates	Filter	Order	Unit 1		Unit 2		Unit 3	
			Activity (c/m)	Retention (%)	Activity (c/m)	Retention (%)	Activity (c/m)	Retention (%)
Nov. 9-13, 1962 (97 hours)	IPC-1478 Type 5G Type 6	1 2 3	120 fpm		280 fpm			
			996.9±3.0	57.85±0.22	2429.0±4.6	65.92±0.16		
			540.7±1.8	31.38±0.13	1050.7±2.5	28.52±0.08		
			185.7±0.6	10.78±0.04	204.8±1.0	5.56±0.03		
			1723.3±3.6	100.01	3684.5±5.4	100.00		
Nov. 23-26, 1962 (76 hours)	IPC-1478 Type 5G Type 6	1 2 3	121 fpm		281 fpm			
			169.8±0.9	52.57±0.34	712.5±1.6	72.62±0.21		
			128.5±0.6	39.78±0.24	241.7±0.7	24.64±0.08		
			24.7±0.5	7.65±0.16	26.9±0.5	2.74±0.05		
			323.0±1.2	100.00	981.1±1.8	100.00		
Feb. 1-4, 1963 (73 hours)	IPC-1478 Type 5G Type 6	1 2 3	119 fpm		280 fpm		622 fpm	
			187.2±1.1	34.53±0.24	629.6±2.0	47.42±0.19	1904.0±3.3	72.90±0.12
			290.1±1.7	53.50±0.37	645.0±2.4	48.58±0.22	690.6±2.5	26.44±0.12
			64.9±0.3	11.97±0.08	53.1±0.3	4.00±0.02	17.3±0.3	0.66±0.01
			542.2±2.1	100.00	1327.7±3.2	100.00	2611.9±6.4	100.00

TABLE 4  
 Reproducibility of the Filter Pack Method as Demonstrated by the Collection of  
 Airborne Fission Products on Duplicate Three-Filter Packs

Collection Dates	Filter	Order	Collection A*		Collection B*	
			Activity (c/m)	Retention (%)	Activity (c/m)	Retention (%)
Jan. 18-21, 1963 (63.5 hours)	IPC-1478 Type 5G Type 6	1	263 fpm			
		2	349.1±2.6	51.34±0.47	385.8±2.7	51.51±0.45
		3	305.3±2.3	44.90±0.41	332.3±2.6	44.37±0.44
			<u>25.5±0.3</u> 679.9±3.5	<u>3.75±0.05</u> 99.99	<u>30.9±0.6</u> 749.0±3.8	<u>4.13±0.08</u> 100.01
Jan. 25-28, 1963 (75 hours)	IPC-1478 Type 5G Type 6	1	281 fpm			
		2	681.3±1.7	51.82±0.17	664.1±1.7	51.77±0.17
		3	592.1±1.9	45.03±0.18	572.8±1.9	44.65±0.18
			<u>41.4±0.3</u> 1314.8±2.6	<u>3.15±0.03</u> 100.00	<u>46.0±0.3</u> 1282.9±2.6	<u>3.59±0.03</u> 100.01

\*Samples from collections A and B counted at same time on different counters; errors shown are the standard deviations based on counting statistics.

TABLE 5  
 Some Measurements of the Penetration of IPC-1478 and Type 5G Filters  
 by Radioactive Particulate Matter

Collection Dates	Activity Measured	Filter	Order	Activity (c/m)	Retention (%)	Penetration (%)
Jan. 18-21, 1963 (63.5 hours)	Fission Products	IPC-1478 Type 5G IPC-1478 Type 6	1	263 fpm		
			2	385.8±2.7	51.51±0.45	48.5
			3	332.3±2.6	44.37±0.44	8.5
			4	1.5±0.5	0.20±0.07	95.
			<u>29.4±0.3</u> 749.0±3.8	<u>3.93±0.04</u> 100.01	<u>0.0</u>	
Mar. 1-4, 1963 (68 hours)	Fission Products	IPC-1478 IPC-1478 Type 5G Type 5G Type 6	1	273 fpm		
			2	478.5±2.1	33.6±0.17	66.4
			3	128.3±1.0	9.0±0.08	86.4
			4	754.4±2.6	53.0±0.23	7.7
			5	50.6±0.3	3.6±0.02	19.3
			<u>12.1±0.3</u> 1423.9±3.5	<u>0.9±0.02</u> 100.1	<u>0.0</u>	
Mar. 27, 1963 (35 min)	RaB+C	IPC-1478 Type 5G IPC-1478 Type 6	1	287 fpm		
			2	23.8±1.1	8.93±0.42	91.0
			3	147.2±2.1	55.26±1.0	39.3
			4	3.7±0.9	1.39±0.34	96.
			<u>91.7±1.7</u> 266.4±3.1	<u>34.42±0.76</u> 100.00	<u>0.0</u>	

obtained from such collections as have been made in this study to mathematical analysis of the size distribution of the radioactive particulates, it is necessary to have a reasonable calibration curve of filter retentivity or penetrability vs particle size in the range of sizes expected. For this purpose a curve has been invented (it has no theoretical justification) to obtain values needed in this analysis. As indicated from the close approximation of the curve (Fig. 3) to measured values of  $H_2SO_4$  retentivity and the residual effectiveness of the filters toward small particles in prefiltered air streams (mentioned above), the plot has some validity. In view of the uncertainty in the density of the radioactive particles or of the inactive material with which they perhaps have become associated, and the uncertain shape of the particle with its effect on particle behavior, the effective density has been assumed to be near that of  $H_2SO_4$  for the purposes of this analysis.

### Mathematical Analysis

Through use of a multifilter pack it is theoretically possible to assign the collected radioactive

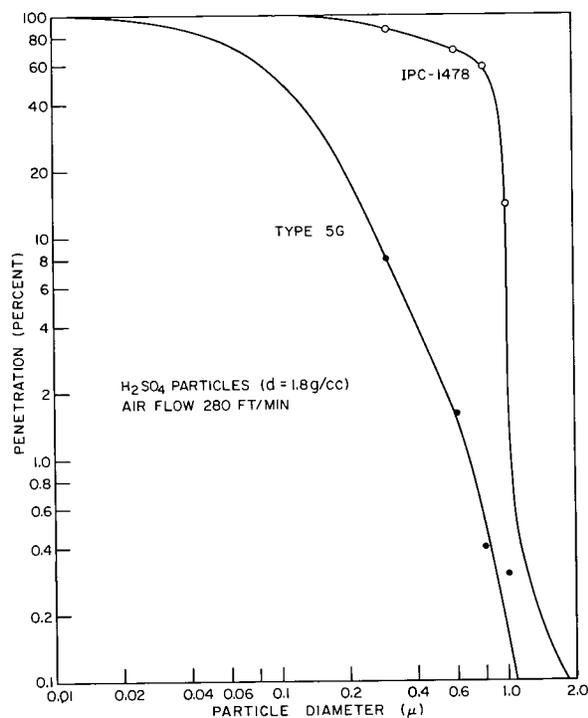


Fig. 3 - Filter penetrability vs particle size

aerosols to an equivalent number of sizes or size groups by use of simultaneous linear equations of the following form:

$$A_1 = x_1 a_1 + x_2 a_2 + \dots x_n a_n$$

$$A_2 = y_1 a_1 + y_2 a_2 + \dots y_n a_n$$

$$A_3 = z_1 a_1 + z_2 a_2 + \dots z_n a_n$$

where  $A_1, A_2, \dots A_i$  are the measured radioactivities (or relative activities) of filters in the 1st, 2nd, and  $i^{\text{th}}$  positions;  $a_1, a_2, \dots a_n$  are the radioactivity values associated with particles in size groups 1, 2,  $\dots n$ ; and  $x_1, x_2, \dots x_n$  and  $y_1, y_2, \dots y_n$ , etc., are coefficients expressing the relative distribution of particles of the different sizes on the filters.

By arbitrarily selecting three particle sizes, namely 1.0, 0.3, and 0.05  $\mu$  diameter, which cover the expected range of sizes, it is possible to derive the coefficients of  $a_1, a_2$ , and  $a_3$  by use of information available in Fig. 3. For example, the IPC filter will retain 86% of the incident 1.0  $\mu$  particles, permitting passage of 14% to the Type 5G filter, which retains essentially all of them. The coefficients of  $a_1$  in the three equations thus become 0.86, 0.14, and 0.00 respectively. By a similar process coefficients for  $a_2$  and  $a_3$  can be estimated. The following equation was developed in this manner and should give reasonable results when solved by determinants (if a judicious choice of coefficients has been made):

$$A_1 = 0.86 a_1 + 0.12 a_2 + 0.00 a_3$$

$$A_2 = 0.14 a_1 + 0.80 a_2 + 0.20 a_3$$

$$A_3 = 0.00 a_1 + 0.08 a_2 + 0.80 a_3$$

This equation has been applied to the assignment of particle size distributions of several collections of airborne radioactivity; the results are given in Table 6. Regardless of the absolute validity of this approach, it does provide a semiquantitative means of presenting differences in the particle size distributions, either the gross differences that exist between fission product as compared to RaB+C activity or the small differences that exist between fission product collections made at different times.

Some four-filter packs have been analyzed on the basis of three particle size groupings by considering the second (IPC) and third (Type 5G)

TABLE 6  
Particle Size Distributions Determined from the Relative Radioactivity of  
Filters in a 3-Filter System

Collection Dates	Radioactive Collection Data				Particle Size Distribution		
	Activity Measured	Filter	Order	Relative Activity (%)	Particle Size ( $\mu$ )	Activity Distrib. (%)	Relative† Particles
Oct. 19, 1962 (30 min)	RaB+C	IPC-1478	1	286 fpm			
		Type 5G	2	7.0	1.0	0.25	1
		Type 6	3	53.9	0.3	56.5	$8.4 \times 10^3$
Nov. 23-26, 1962 (76 hours)	Fission Products	IPC-1478	1	281 fpm			
		Type 5G	2	72.62	1.0	82.2	1
		Type 6	3	24.64	0.3	16.0	7.2
Jan. 18-21, 1963 (63.5 hours)*	Fission Products	IPC-1478	1	263 fpm			
		IPC-1478	2	51.34	1.0	65.1	1
		Type 5G	3	8.68	0.3	33.6	19
		Type 6	4	36.23	0.05	1.33	160
Jan. 25-28, 1963 (75 hours)	Fission Products	IPC-1478	1	281 fpm			
		Type 5G	2	51.82	1.0	53.7	1
		Type 6	3	45.03	0.3	47.1	32
Mar. 15, 1963 (30 min)*	RaB+C	IPC-1478	1	284 fpm			
		IPC-1478	2	9.0	1.0	8.8	1
		Type 5G	3	4.3	0.3	47.9	200
		Type 6	4	48.2	0.05	43.3	$3.9 \times 10^4$
Mar. 27, 1963 (30 min)*	RaB+C	IPC-1478	1	287 fpm			
		IPC-1478	2	9.91	1.0	10.9	1
		Type 5G	3	5.69	0.3	52.0	175
		Type 6	4	50.57	0.05	37.1	$2.7 \times 10^4$

\*Information obtained from a four-filter pack; filters in positions 2 and 3 considered as a single filter.

†Assuming constant specific activity.

filters together as equivalent to a single (Type 5G) filter. The results of these determinations are also included in Table 6. The four-size group assignments have not been included because negative percentages have been obtained in the mathematical analysis, which indicates that some adjustment will be required in the assignment of coefficients in the simultaneous equations.

The three natural radioactivity collections (RaB+C) show approximately the same size distribution with the major part of the radioactivity divided between the 0.3 and 0.05  $\mu$  size groups. Fission products on the other hand showed more variation in size with time (probably directly related to the freshness of nuclear debris in the air) and a much lower concentration of radioactivity in the smaller size group. Over half (50 to 80%) of the fission product radioactivity was assigned to particles in the 1.0  $\mu$  size group. In each of these analyses assignments have also been made of the number of particles in each grouping by assuming a constant specific activity of the particles and a spherical shape. The association of natural activity with small particles is clearly evident; however, the

smaller particles probably have a higher specific activity than do the large ones, and consequently the relative number of small particles is exaggerated.

### Effect of Age on Size of Fission Debris

Information collected during the past six months on the retentivity of IPC-1478 filters for fission product radioactivity at two different flow rates is shown in Fig. 4. A relatively large effective particle size is indicated for these debris during the latter part of 1962 while atmospheric nuclear testing was being carried out. A progressive decrease in the particle size with elapsed time after cessation of such testing is indicated by measurements during early 1963. It is anticipated that the effective particle size will level off as the larger particles are lost from the atmosphere and that perhaps thereafter the measured particle size will be the result of agglomeration or attachment of smaller fission product particles to normal atmospheric aerosols. Subsequent size changes might be a reflection of the residence times of the radioactive particles in the troposphere or of the deposition mechanisms acting on the normal (non-radioactive) airborne dust and particulate matter.

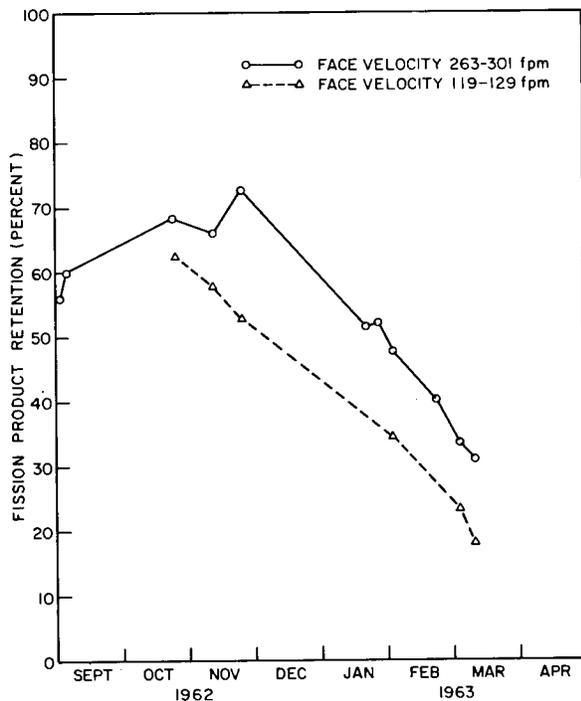


Fig. 4 - Observed temporal differences in the retentivity of IPC-1478 filters for airborne fission product radioactivity

### Composition of Deposits

No measurements of comparative radioactive decay rates or of radioisotope distribution patterns among the various filters in the packs have been made. However, past experience with fresh debris has shown definite evidences of isotopic fractionation (1,2). Consequently, large collections of airborne fission products are currently being collected routinely on three-filter and four-filter packs of the IPC-1478 (one or two filters), Type 5G, and Type 6 (Navy N-15) papers for future analysis. Each collection is of approximately five to seven days duration at a flow rate of about 175 cubic feet per minute or at a linear velocity near 130 fpm (calibration presently incomplete). The dimensions of each filter are about 13 x 17 inches (overall).

The present plan is to undertake the radiochemical analysis of filters from representative filter packs for such  $\beta$ -emitting isotopes as Sr<sup>89</sup>, Sr<sup>90</sup>(Y<sup>90</sup>), Y<sup>91</sup>, Cs<sup>137</sup>, Ce<sup>141</sup>, Ce<sup>144</sup>(Pr<sup>144</sup>), Pm<sup>147</sup>, and Pb<sup>210</sup>. Differences in the ratios of the various isotopes on the different filters in the pack to some one of them used as a reference will indicate the

degree of fractionation of the particular isotopes with particle size.  $Pb^{210}$  (RaD), a descendent of radon from the soil, is of interest since its mode of formation is through a natural process rather than through nuclear fission; furthermore, its distribution and concentration in the troposphere and its half-life are very similar to those of  $Sr^{90}$ .

The distribution of fission products within the particle size ranges may bear some relation to the increased rate of downward mixing of activity from the stratosphere during the spring season or to differences in tropospheric residence times during the various seasons. In the event of continued testing of nuclear weapons in the atmosphere, changes in the particle size distribution and in the distribution of radioisotopes with particle size in fresh debris can be observed.

### CONCLUSIONS

Preliminary measurements have shown the multifilter technique to give reproducible results and to differentiate readily between the particle size distributions existing in natural and fission-product-containing aerosols. The present investigation suggests that this technique will provide useful information on the size distribution of radioactive particulate matter in the atmosphere as a function of meteorological and seasonal factors and the age of fission product contaminants in the air. A knowledge of this size distribution would be of extreme value to studies relating to

the mechanism of precipitation scavenging of radioactivity and the dry deposition of fallout.

Through radiochemical studies of similar collections a determination can be made of the extent of the fractionation of isotopes relative to one another in the different size groups; the information can be interpreted in terms of the processes occurring during the cooling and condensation phases involving bomb debris immediately following a nuclear explosion. The isotopic distribution may also be modified by the various deposition processes acting selectively on certain size groups of airborne particles.

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