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Performance Characteristics of the FPP-15 Filter Material Used in the USSR for Environmental Radioactivity Monitoring

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ABSTRACT

A survey of the physical properties and operational characteristics has been made of the FPP-15 filter paper widely used in the Soviet Union for monitoring airborne radioactivity.

This filter material is composed of a thin mat of small-diameter, unoriented fibers of polyvinyl chloride deposited on a cotton scrim backing. Due to its composition, the filter readily picks up an electrostatic charge which causes some difficulty in handling but which contributes to an increased initial retentivity toward submicron aerosol particles. Functionally, the filter combines low resistance to air flow with good retentivity toward fission-product aerosols.

PROBLEM STATUS

This is a final report on this phase of the problems; other work on these problems is continuing.

AUTHORIZATION

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PERFORMANCE CHARACTERISTICS OF THE FPP-15 FILTER MATERIAL USED IN THE USSR FOR ENVIRONMENTAL RADIOACTIVITY MONITORING

INTRODUCTION

In a recently published report,* a comparison was made of the more important characteristics of filter materials which are used for monitoring airborne radioactivity throughout the world. Although an exceedingly wide spectrum of filter materials was covered in this report, no information was reported on the materials used in the Soviet Union by their extensive networks.

Recently, samples of the filter material known as FPP-15 ($\phi\pi\pi$-15-1.5) were obtained in an exchange of filter media arranged through the auspices of the National Academy of Sciences of the United States and the Academy of Sciences of the USSR. The characteristics of this filter material have been obtained by methods described in detail previously and are presented here as a supplement to NRL Report 6054.*

DESCRIPTION OF FPP-15 FILTER

The FPP-15 filter is composed of a thin mat of unoriented synthetic fibers (polyvinyl chloride) deposited on a cotton scrim backing. The individual fibers have an average diameter of about 1.5μ (range 0.5-2.5μ) as determined from observation under an optical microscope. Most of the fibers are flat, ribbonlike filaments, but a few have a circular cross section. Due to the extremely low electrical conductivity of polyvinyl chloride, the filters readily acquire a static charge that makes handling difficult.

A summary of the physical characteristics of the FPP-15 filter and several other representative filter media is given in Table 1. Air flow performance was determined for 4-in.-diam filters (effective area 60.0 cm^2). Filter clogging rates were obtained relative to Gelman A glass fiber filters and Type 5G cellulose/glass filters used as references; an average clogging rate of $0.5\%/m^3/cm^2$ had previously been obtained for the Gelman A filter.

PARTICLE RETENTION

A laboratory evaluation of the penetration of the FPP-15 filter by 0.3μ-diam dioctyl phthalate (DOP) aerosol at various linear velocities through the filter was made using the standard procedures described in NRL Report 6054. The results are contained in Table 2. It can be seen from the table that the initial penetration was low at all flow rates, but during a short interval of continuous flow (5-60 sec, depending upon flow rate), it increased uniformly to the final value. Once this final penetration value was achieved, only negligible changes in penetration with time were observed. The high initial retentivity has been

*L. B. Lockhart, Jr., R. L. Patterson, Jr., and W. L. Anderson, "Characteristics of Air Filter Media Used for Monitoring Airborne Radioactivity," NRL Report 6054, March 1964.

Table 1
Summary of Physical Characteristics of Representative Filter Media

Filter	Type	Thickness (mm)	Tensile Strength (Kg/cm)	Weight (mg/cm^2)	Ash Content		Performance in Standard System		Effect of Dust Loading	
					(%)	(mg/cm^2)	Flow (m^3/hr)	Pressure (cm Hg)	Volume filtered at 10% reduction in flow (m^3/cm^2)	Decrease in flow (%/m^3/cm^2)
FPP-15	Synthetic fiber (polyvinyl chloride)	0.34	1.98†	7.0	0.27	0.019	46.5	4.0	33.0±2.6(5)*	0.30
Microsorban	Synthetic fiber (polystyrene)	1.55	0.15	21.7	<0.10	0.016	39.1	7.3	47.6±13.3(6)	0.21
Type 5G	Cellulose/glass fiber	0.76	1.31†	14.9	8.08	1.20	48.6	1.4	50.1±5.9(8)	0.20
Type 6	Cellulose/asbestos	1.22	0.19	28.1	9.97	2.79	35.2	10.0	39.4±10.6(6)	0.25
Whatman No. 41	Cellulose	0.25	1.41	8.9	<0.10	<0.01	33.8	10.8	2.00±0.28(5)	5.0
Hurlburt 934H	Glass fiber	0.30	0.10	6.8	99.5	6.75	33.8	11.1	21.3±4.2(6)	0.47

*Number of observations indicated in parentheses.
†Filters have a scrim backing for added strength.

attributed to the presence of an electrostatic charge which was subsequently dissipated. Verification of the existence of this charge was obtained by subjecting the original filter media to x-ray irradiation and then evaluating the penetration. A filter treated thusly showed no progressive increases in penetration with respect to time; only values equivalent to the final penetration values mentioned previously were obtained. It is interesting to note that the total amount of DOP retained by the filter during its transition from the initial to the final penetration value is equivalent to one monolayer of DOP spread over the entire fiber surfaces. The liquid DOP thus appears to be the means of discharge of the static charge. The final penetrations obtained are shown in comparison with other media in Table 3. The closest counterpart of this media is the Type 5G. Table 4 shows the resistance to air flow in terms of pressure drop across these same filters at various linear velocities through the filters. The presence or absence of the electrical charge has no effect on the resistance measurements.

Table 2
DOP Smoke Penetration as a Function of Velocity

Flow Rate (cm/sec)	Initial Penetration (%)	Final Penetration (%)
14.2	1.0	23.0
35.3	3.0	24.0
71	5.0	21.0
141	4.0	12.0
283	1.5	3.0

Table 3
Comparison of DOP Smoke Penetration of FPP-15 and Other Filter Media

Filter	Penetration (%) of 0.3μ DOP Particles at Various Flow Rates				
	14.2 cm/sec	35.3 cm/sec	71 cm/sec	141 cm/sec	283 cm/sec
FPP-15	23.	24.	21.	12.	3.
Microsorban	0.20	0.26	0.20	0.090	0.002
Type 5G	30.	32.	32.	24.	12.
Type 6	0.003	0.004	0.001	0.000	0.000
Whatman No. 41	34.	22.	9.	0.75	0.020
Hurlburt 934AH	0.009	0.008	0.004	0.002	0.000

The retention of the filter for fission-product radioactivity and natural radioactive aerosols present in the atmosphere was determined at several flow rates through use of a filter pack technique. In this procedure the radioactivity deposited on the test filter was compared with that which penetrated the filter and was collected on an "ultimate" filter (Type 6). Short collection periods (30 min) and immediate counting were employed in determining the retention of the short-lived natural radioactivity (RaB+C); long collection periods (2-4 days), followed by a minimum waiting period of 7 days, were employed in determining the retention of fission products. The retentivities of FPP-15 filters and of Type 5G filters toward these radioactive aerosols are shown in Table 5. The unexpectedly high retention of the FPP-15 filter for RaB+C activity at the lowest flow rate is perhaps due to an electrostatic effect. If such was the cause, it is evident that the 30-min exposure did not completely dissipate the charge.

Table 4
Relationship of Pressure Drop to Flow Rate for Various Filter Media

Filter	Pressure Drop (mm Hg) at Various Flow Rates						
	35 cm/sec	53 cm/sec	71 cm/sec	106 cm/sec	141 cm/sec	211 cm/sec	283 cm/sec
FPP-15	4.5	6.9	9.2	13.7	18.4	27.5	37.1
Microsorban	14.	21.	29.	43.	57.	85.	112.
Type 5G	3.	5.	7.	10.	14.	21.	28.
Type 6	22.	32.	43.	67.	86.	130.	192.
Whatman No. 41	24.	36.	48.	72.	95.	146.	194.
Hurlburt 934AH	25.	37.	50.	74.	99.	150.	198.

A longer pack collection (16 hr) was subsequently made and analyzed for RaB+C, ThB+C, and fission products through measurement of the activity on the initial and final filters during the first, sixth through tenth, and 70th through 74th hours following termination of the collection. The results of this determination are shown in Table 6. Since the collected RaB+C activity is representative of the air concentration of this activity only during the last several hours of the collection, effectively this meant the filter was being evaluated for retention of RaB+C after some 14 hr of exposure to a moving air stream. This should have been sufficient to neutralize any static charge. It is apparent that considerably higher penetration of the RaB+C and also ThB+C activities occurs under these conditions at the lower flow rate, giving some credence to the idea that the initially high retentivity was due to a static charge. At the higher flow rates a more rapid neutralization of the electrical charge would take place; evidently it had been effectively eliminated during the 30-min exposure period in the collections described in Table 5.

CONCLUSIONS

The Soviet FPP-15 filter material is composed of a thin, uncompacted mat of small diameter, unoriented fibers of polyvinyl chloride, a synthetic polymer. It is similar in appearance and construction to the well-known polystyrene fibrous filters, but with a lower resistance to air flow. Because of the high electrical resistivity of polyvinyl chloride, the FPP-15 filters readily acquire an electrostatic charge which causes some difficulty in handling and mounting in a filter holder. On the other hand, this electrical charge apparently contributes to the effectiveness of the filter in its retention of submicron aerosol particles, at least during the initial filtration period.

After dissipation of the electrostatic charge through normal operation of the filter device, the retention characteristics of the filter are similar to those of other filter media having comparable flow characteristics. The FPP-15 filter is an effective material for use in systems designed for monitoring airborne fission products at ground level.

Table 5
Measured Retention of Radioactive Aerosols by the USSR FPP-15 and US Type 5G Filters

Filter	Date of Collection	Weather	Unit A		Unit B		Unit C	
			Air Velocity (cm/sec)	Retention* (%)	Air Velocity (cm/sec)	Retention* (%)	Air Velocity (cm/sec)	Retention* (%)
Natural Radioactivity (RaB+RaC)								
FPP-15	4/15/64	Cloudy	69	95.2±1.0	147	90.2±0.4	270	92.0±0.3
	6/9/64	Clear	71	97.7±0.4	144	93.2±0.4	311	95.8±0.1
	6/10/64	Clear	69	97.0±0.5	146	94.7±0.2	285	97.2±0.1
Type 5G	4/15/64	Cloudy	70	62.1±2.0	150	58.6±1.4	295	71.9±0.5
	6/9/64	Clear	71	69.5±1.0	150	77.2±0.5	336	81.9±0.3
	6/10/64	Clear	70	69.6±0.8	148	77.6±0.4	344	85.7±0.2
Fission Products in the Atmosphere								
FPP-15	2/28-3/2/64	Snow	69	99.0±0.2	137	99.5±0.1	162	99.8±0.1
	3/2-3/3/64	Rain	-	-	-	-	291	99.5±0.2
	3/9-3/13/64	Clear/Rain	69	98.9±0.1	138	99.6±0.1	219	99.8±0.1
Type 5G	3/16-17/64	Clear	72	87.2±0.5	149	95.6±0.3	286	99.3±0.2

*Uncertainty shown is standard deviation (σ) based on counting statistics.

Table 6
Effect of the Length of Collection on the Retention of Radon Decay Products by FPP-15 Filters

	Filter Retention (%)		
	Activity	16-hr Collection*	30-min Collection†
Unit A Linear Velocity 70 cm/sec	RaB+C	84.9±0.7‡	96.6
	ThB+C	87.7±2.3	-
	Fission Products	97.8±0.6	-
Unit C Linear Velocity 283 cm/sec	RaB+C	95.8±0.1	95.0
	ThB+C	95.6±0.4	-
	Fission Products	100.0±0.1	-

*Collections made 1600 EDT June 18 to 0820 EDT June 19, 1964.
†Average of values from Table 5.
‡Indicated uncertainty is the standard deviation (σ) based on counting statistics.

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