PRELIMINARY REPORT
on
COTTON AEROSOL FILTER STUDIES

by

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I. Introduction

The discharge of several materials to the atmosphere can create public health problems. Consequently, the further development of satisfactory low cost air cleaning devices may play a part in health protection by encouraging the use and installation of air cleaning facilities. The use of cotton fibers as filter media has prospects for economy because cotton has a relatively low initial cost, has low ash (less than 0.1% (1)) for economical disposal and is readily available.

During the past year, studies have been conducted at the Harvard University Air Cleaning Laboratory on the filtration characteristics of various cotton fibers for atmospheric dusts. Four natural fibers and two ion exchange coatings were investigated.

In conjunction with the basic cotton work a parallel study was conducted on the correlation of weight, stain, and count efficiencies for atmospheric dust. If an empirical relationship can be developed using atmospheric loadings, considerable time can be saved in obtaining an index of count and weight efficiencies from a simple stain technique.

In an attempt to reduce the weight efficiency variation caused by a few large particles a prefilter was used. This introduced a third phase of the

study which had as its goal the evaluation of the prefilter as a means of obtaining a relatively consistent aerosol for filter rating.

II. Equipment

Figure 1 is a schematic diagram of the test setup. The prefilter had a face area of 0.143 square feet and consisted of 10 layers of Metex mist eliminator screen coated with SAE 30 motor oil.

The napped cloth was used to interlace with the test medium to minimize edge leakage.

Fiber Description

A cotton fiber has been described as an epidermal cell of the seed. It consists of an outer wall, secondary wall and a lumen. With growth, the secondary wall thickness increases until the lumen is nearly closed. With the drying that occurs after picking, the lumen collapses and for mature fibers a kidney or elliptical shape is attained. In immature fibers the secondary wall is thin and upon collapse of the lumen the fiber attains a twisted ribbon or U-shape. Matthews (2) indicates that wall thickness may vary from 0.35 to 15 μ and ribbon widths from 11 to 20 μ.

The fibers tested in this series were sized by Rosano (3). The mean diameters presented in Table I are the geometric means of single transverse measurements of over 200 fibers for each grade.

The Lockett sample contained about 93% mature fibers and the Memphis immature about 38% mature fibers.

The ion exchange treatments which were tested had been applied to S x P fibers by the U. S. Department of Agriculture. The resin treatment was impregnation by Resiloom HP, an unmethylated methylolmelamine resin which has found use in ion exchange columns. The aminized cotton had been treated with

2-aminoethylsulfuric acid and sodium hydroxide. Aminized cotton has anion exchange properties and the treatment facilitates the use of acid dyes.

Test Procedure

A. Bed Preparation

The fibers tested had been furnished by the U. S. Department of Agriculture, Bureau of Agricultural and Industrial Chemistry, New Orleans, Louisiana. They were received as card slivers and difficulty was experienced in obtaining reproducability. The fibers were carded again and taken off as card web which was folded into boxes for storage. Compaction in storage made most of the individual layers of the web indistinguishable. The layers were separated by hand as well as possible and cut into six inch squares. The weight necessary to give a packing density of 2 lbs. per cubic foot (porosity 0.98) was computed (cotton specific gravity 1.59). Depending upon the type of fiber and the degree of compaction, five to ten layers were required per inch of final pad. These layers were loosely placed in the plastic box and compressed to the desired bed depth by insertion of the inside section. With this technique packing densities could be satisfactorily reproduced.

B. Operation of Test Apparatus

The combined operation of the upstream and downstream high volume samplers brought room air into the plenum through the prefilter at 50 cfm (face velocity of 350 fpm). One-half of this flow went to the upstream high volume sampler and the other half went through the test section to the downstream high volume sampler.

Stairmand discs were used as orifice meters to determine the respective flow rates. The 25 cfm rate through the test section gave a face velocity at the test pad of 100 fpm. Continuous operation of from 48 to 80 hours on Boston

air was required to produce significant increase in the weight of the downstream sampling filters.

C. Sampling

Samples were taken at three points: 1. Room air (upstream of prefilter), 2. Upstream (downstream of prefilter, upstream of cotton pad), 3. Downstream (downstream of cotton pad).

Weight loading was determined at these three points by determining the net weight increase of type S pleated filters. The room air sample was collected at full flow of the high volume sampler which varied from 70 cfm to 40 cfm. Both upstream and downstream samples were taken at 25 cfm with the entire volume passing through the test pad collected for the downstream sample.

After from 10 to 20 hours of operation, and again 24 to 48 hours later, membrane filter samples were taken at 0.7 cfm for count loading and stain efficiency determinations. The room air membrane filter sample was taken near the prefilter and the upstream and downstream samples were taken through probes in the test section. These samples were taken for 45 to 120 minutes, depending on the rate of stain buildup. At intervals of 15 to 20 minutes the stain density of each membrane filter was determined by use of a Photovolt, Model 200A transmission densitometer.

A blank for zeroing the densitometer on each membrane filter was obtained by backing each filter with Whatman #1 paper to which a 5/8" circle of cellophane tape was attached. With this backing, the stain was deposited in an annular pattern and the center portion of the filter remained clean.

D. Analysis

The stain readings were plotted against time for each filter and the time to reach a constant stain was determined from each curve. The stain efficiencies were then determined from the relationship

$$\% \text{ Efficiency} = \left(1 - \frac{t_1}{t_2}\right) \times 100$$

The membrane filter stains were then counted and sized microscopically under oil immersion (90X objective and 25X eyepiece) to determine the count loading and size distribution at each sampling point. Total efficiency, by count, and size fraction efficiencies were determined from these loadings.

Test Results

Analysis of the data has not been completed, but a summary of weight, stain and count efficiencies is presented in Table I for the various fibers tested. These efficiencies are tabulated in order of decreasing weight efficiency.

The pressure drops listed in Table I are the final drops observed in the respective tests. These values represent no appreciable increase over the drop in the clean beds for the shorter operating periods (48 to 60 hours). For resin treated S X P and Memphis Immature beds there were 7 and 11 percent

TABLE I

Efficiencies of 2" Pads of Various Cotton Fibers on Atmospheric Dust
Packing Density 2#/ft^3
Face Velocity 100 fpm

Cotton	Mean Fiber Diameter μ	Weight Efficiency %	Stain Efficiency %	Count Efficiency %	Pressure Loss Inches of Water
Memphis Immature	10.0	82.5	78.8	63.5	5.8
Aminized S x P	10.0	80.5		57	3.0
Untreated S x P	9.4	77	72.7	58.5	4.0
Resin Treated S x P	10.3	74.8	72.5	61	3.6
Lockett 140	13.4	71.3	46	39	2.1
Iquitos	15.5	67	46		1.6

To date, the only variables studied have been type of fiber and bed depth. Further studies are planned to test the fiber at different packing densities and face velocities. It is planned to delay further cotton studies until the present data on relationships of weight-stain and count-stain efficiencies are more completely analyzed and the value of the prefilter is established. Using the present techniques, about 5 days are required for each run in order to collect weighable samples and count and size the 6 molecular filters. From a preliminary inspection of the weight-stain relationship it appears that empirical relationships might be derived which will reduce the time from days to hours for each run.

If these relationships do not prove reliable, a synthetic test aerosol will be generated and the cotton tests continued. Future studies will evaluate the effects of various packing densities and various face velocities.

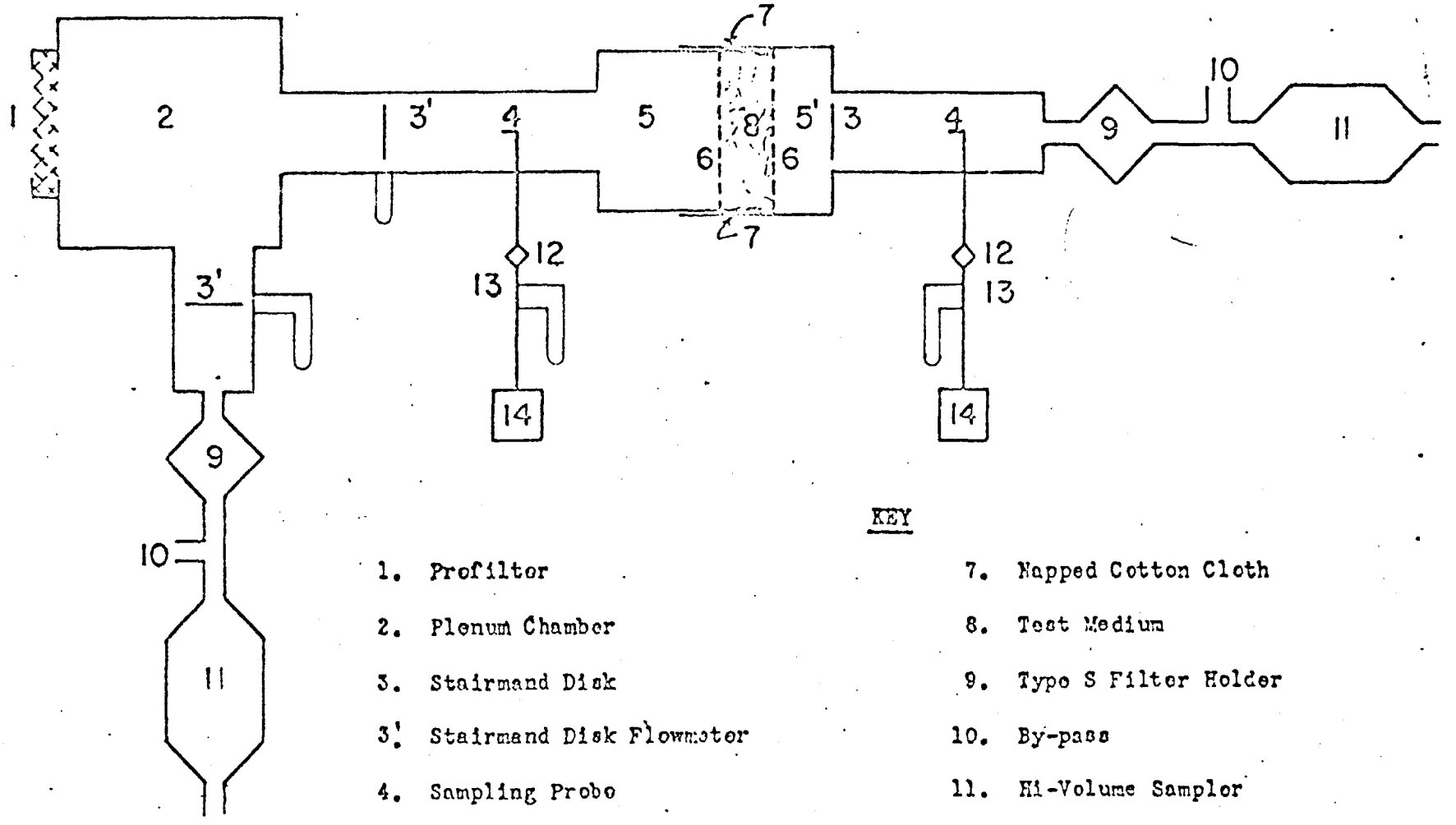
Prefiltration

Partial analysis of the data indicates that the prefilter causes little change in aerosol composition. The average size fraction efficiencies of the prefilter were determined from the data of 28 runs. The average cloud composition for room air was determined from the same data. This average composition was plotted on logarithmic probability paper and, using the average size fraction efficiencies, a second cloud was synthesized which represented a cloud leaving a prefilter of average performance. The line representing this second cloud on logarithmic probability paper was almost superimposed on the initial line. This approach clearly shows that present sizing techniques are insensitive to any changes made in the aerosol composition by this type of prefilter.

It is felt that the major benefit to be derived from the prefilter is in the removal of large particles which may distort any empirically determined relationship between stain and weight efficiencies.

FIGURE 1

COTTON TEST EQUIPMENT



KEY

1. Prefilter
2. Plenum Chamber
3. Stairmand Disk
3'. Stairmand Disk Flowmeter
4. Sampling Probe
5. 6" Plastic box (inside section)
5'. 6" Plastic box (outside section)
6. Wire Screen Support
7. Napped Cotton Cloth
8. Test Medium
9. Type S Filter Holder
10. By-pass
11. Hi-Volume Sampler
12. Membrane Filter Holder
13. Flowmeter
14. Leiman Pump

REFERENCES

1. Silverman, Leslie and Viles, F. J., Jr. Determination of Cotton Textile Dusts in Air. Textile Research Journal, Vol. XX, No. 2, Feb. 1950.

2. Matthews, J. M. Textile Fibers. Wiley & Son, 1948.

3. Rossano, A. T., Jr., U. S. Public Health Service and Harvard School of Public Health - private communication.