10025 Division Office

NATIONAL BUREAU OF STANDARDS REPORT

10 025

EVALUATION OF AIR FILTER MEDIA

Report
to
Bureau of Research and Engineering
Post Office Department
Washington, D. C. 20260

NBS

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D. C. 20234.

[2] Located at Boulder, Colorado 80302.

[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT | **NBS REPORT**

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EVALUATION OF AIR FILTER MEDIA

by

Charles M. Hunt

Environmental Engineering Section
Sensory Environment Branch
Building Research Division
Institute of Applied Technology

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Summary

1. In laboratory tests polyurethane foam media was found to be somewhat superior to fiber glass media in arresting atmospheric dust or fly ash (Cottrell precipitate).

2. At the Philadelphia Post Office polyurethane was slightly inferior in dust arrestance to fiber glass in one set of measurements and approximately equal in three other sets. Arrestance values of both media were higher in August than in October, November, or December.

3. Polyurethane foam was found to develop greater resistance to air flow than fiber glass when both were highly loaded with dust. This was true whether artificial dust or dust from the Philadelphia Post Office was used.

4. When estimates of polyurethane usage, based on 149 days service, were compared with estimates of fiber glass usage, based on 1963 - 1967 service records, the polyurethane significantly outlasted the fiber glass.

5. The reason for the paradox that polyurethane outlasts fiber glass even though it has a lower dust holding capacity is not known. One explanation which is under consideration is that appreciable amounts of media may be wasted due to triggering the pressure switches by transient pressure changes. It is postulated that less polyurethane is wasted through this mechanism because of its thinner construction and smaller take-up rolls.

6. A tentative annual cost estimate for operating filters in the Main Post Office at Philadelphia is approximately $2900 for polyurethane and $3400 for fiber glass, or about a 15 percent saving.

Evaluation of Air Filter Media

by

Charles M. Hunt

1. Introduction

The technical objective of this project is to evaluate the dust-arresting performance and usage of open-cell polyurethane foam and fiber glass roll filter media when used as prefilters in space conditioning units in the Philadelphia Post Office. The purpose is to obtain comparative performance and media consumption data for foam media and for fiber glass media now used by the Post Office, with a view to decreasing the annual cost of prefilters, and obtaining equal or better filtering performance.

The approach used was threefold. 1. Polyurethane foam media was installed in the air handling units at the Philadelphia Post Office, and media usage was compared with past records of fiber glass usage. 2. Certain pairs of units were set aside as special test units. In these units fiber glass media was placed in one and polyurethane foam in the other, and comparative arrestance, usage, and other data were obtained on the two types of media. 3. Laboratory measurements of dust arrestance and the resistance to air flow of clean and dirty filters were made.

The polyurethane media was provided by Unifilter Incorporated of Malvern, Pennsylvania, under a contract to furnish and install all needed media on a fixed monthly service charge for an 11-month period. Unifilter was also required to keep an accurate record of quantities of media used and dates of replacement of filters. This report includes usage data for 5 months of the 11 month period. A supplement to this report will be issued to include remaining usage data.

The National Bureau of Standards made dust-arrestance and other performance measurements in four weekly periods during the 11 months, that correspond to summer, fall (2) and winter seasons and also performed tests in the laboratory. The Plant Engineering Department of the Philadelphia Post Office provided fiber glass filter usage data from 1963 - 1968 for analysis and comparison with polyurethane data.

It should be emphasized that at the present time there are no generally accepted methods for the field testing of low efficiency filters. For this project means of test had to be devised and, therefore, the project was also a testing ground for the methods of evaluation. Some modifications of testing plans and procedures were made as data and results became available.

2. Description of Filters

The polyurethane media was Scott Industrial Foam media marketed under the name of Clean-rite. It consisted of a 1/4 inch thick layer of 15 ppi (pores per inch) foam on a 1/8 inch backing of 60 ppi foam with an interlayer of reinforcing square weave scrim (Leno weave) of 3-threads per inch. It was manufactured by the Foam Division of the Scott Paper Company of Chester, Pennsylvania.

The fiber glass filter media consisted of a mat of randomly oriented glass fibers about 1 1/2 to 2 inches thick in the uncompressed condition. The fibers on the front surface were blue, but most of the fibers were colorless. There was no scrim or wire backing on the filter, but the back layer consisted of a thin mat of glass fibers cemented together with a binder. Typical fiber diameters were 30 to 40 micrometers (microns) with a few larger fibers more than 40 micrometers and some as small as 15 micrometers. The media was marketed by the Drico Industrial Corporation of Wallington, N. J. under the name of Filtrex roll filter media.

Both the polyurethane foam and the fiber glass media contained viscous adhesive to aid in the capture and retention of particles.

3. Results

A. Dust Arrestance

a. Laboratory determination of dust arrestance

Eighteen inch-square panels of polyurethane foam and fiber glass were tested for efficiency in removing normal atmospheric dust and Cottrell precipitate from laboratory air. The filters were placed in a test duct and air drawn through at an average face velocity of 500 ft/min. The method of determining arrestance consisted of sampling equal volumes of air upstream and downstream from the filter. The samples were drawn through filter papers and the comparative amount of dirt was estimated photometrically. Dust arrestance was calculated from the equation,

$$A = 100\ (1 - F\frac{\Delta D}{\Delta U})\ , \qquad (1)$$

where A is percent arrestance, ΔD is the decrease in light transmission through the downstream sampling paper due to the dust spot, ΔU is the corresponding decrease in transmission through the upstream paper, and F is the ratio of the areas of the downstream and upstream dust spots. The need for the factor, F, arises from the fact that if the filter removes dirt, the downstream sampling paper will be lighter than the upstream paper. However, if equation 1 is to give an accurate estimate of arrestance, it is desirable that ΔD and ΔU be approximately equal. Therefore the sampling areas were controlled by using paper holders with different size openings to equalize ΔU and ΔD. The foregoing method of test is the NBS dust spot method. It was originally developed by R. S. Dill [ASHVE Transactions, Vol. 44, page 379 (1938)], and is sometimes referred to as the "discoloration method" or "staining test".

Arrestance values of polyurethane and fiber glass media obtained with normal atmospheric dust at Gaithersburg are shown in table 1. The air at Gaithersburg is very clean compared to air the Philadelphia Post Office, and the dust is predominantly of very small particle size. Under these circumstances the efficiency of both media was low and the repeatability poor. The negative arrestances mean that sometimes slightly more dirt was found on the downstream sampling paper than on the upstream paper. Low arrestance values and poor repeatability are common observations when low efficiency filters are tested for atmospheric dust arrestance with comparatively clean air.

The difference between the two samples of polyurethane media was rather large. One was distinctly more efficient than the fiber glass, whereas the other was only slightly so. Also the efficiency of the filters seemed to improve with repetition even though they remained clean in appearance. It was thought that this increase might be due to development of an electrostatic charge on the filter as air was drawn through, but no charge was detected with a Keithly electrometer.

Arrestance measurements were also made using Cottrell precipitate (fly ash) dispersed in air as the test aerosol. This material has a much higher average particle size than atmospheric dust, and arrestance values are higher. The upper curves in figure 1 show the arrestance of Cottrell precipitate by polyurethane and fiber glass media as a function of increasing amounts of dirt on the filters. The first sample of polyurethane had an average arrestance about 83 percent while the other had a value of 75 percent. Both were more efficient than the fiber glass, which had an average arrestance of about 68 percent.

b. Dust arrestance at the Post Office

Comparative arrestance measurements of polyurethane foam and fiber glass were made at the Philadelphia Post Office using paper tape samplers. These devices sample air through paper tape for a preset period of time, after which a shift mechanism moves the paper tape, and a new spot is started. In this way a series of dust spots is obtained representing samples taken at regular intervals for any desired period of time. By placing one of these samplers ahead of the filter and another behind it, filter arrestance values were obtained.

Arrestances obtained with fiber glass and polyurethane foam are shown in table 2. Measurements were made in August, October, November and December and they represented both day and night operating conditions. The August measurements indicated that the fiber glass was somewhat more efficient than the polyurethane. This is contradictory to laboratory observations. October, November, and December measurements, on the other hand, indicated that the two media were about equally efficient. All of the arrestance values were highly variable as indicated by the large standard deviations of individual arrestance values about the average. A large part of this variability arose from the paper tape method itself because of variations in the optical density of the paper. Also the sampling rates were not as well controlled as in laboratory measurements. However some of the largest variations in table 2 may possibly reflect time variations in the efficiency of the filters themselves.

Disregarding arrestance and considering only the upstream dust spots, it is possible to make some comparisons between dust levels in the air handling units as is done in table 3. In October, November, and December the dust levels in the polyurethane and fiber glass units were nearly equal, while in August, unit 2A which contained glass fiber had a consistently higher dust level than 2B which contained polyurethane. If a high dust level were due to the presence of freshly generated dust, the average particle size would most likely be comparatively large, and this should contribute to higher arrestance values. This suggestion is offered to explain the higher arrestance of the fiber glass in August which is contrary to results obtained in October, November, and December, as well as results obtained in the laboratory.

Arrestances for both types of media were higher in August than in October. Also in October arrestances were slightly higher than in November and December, although the latter differences are close to experimental error. The reason for this decrease in arrestance is not known. There was more return air passing into the air handling units in August than during the other periods. However, there was also a little more return air used in December than in October or November. The return air would contain dust generated in the building which might be expected to have a larger average particle size. Another suggestion is that temperature affects the viscosity of the filter adhesive, and this in turn might influence filtration efficiency. Humidity might also play a role.

Other details which might be mentioned in connection with the arrestance data in table 2 are, the change in the length of the sampling cycle, and the transfer of the media to different units. Measurements in August and the first measurements in October were made by sampling two hours per spot. Subsequent measurements were made with a one hour sampling cycle. The length of the cycle was reduced to allow an extra factor of safety in case the dust level was to become so high that optical densities of the dust spots would no longer adequately measure differences in dust level. It is also to be noted that the August measurements were made with the fiber glass media in unit 2A and the polyurethane in unit 2B, while in the October measurements the location of the two media was reversed. The change was made because the air velocity and air turbulence in 2A and 2B were different. This is discussed further in connection with filter usage in these units. The comparison of the two media was then transferred to units 2C and 2D where the November and December arrestance measurements were made. The floor diagrams of the upstream part of the four test units are given in figures 3 and 4.

B. Dust holding capacity and air flow characteristics

The same 18 inch- square filter panels which were tested for dust arrestance were also tested for dust loading characteristics. For this purpose a test dust consisting of 96 percent Cottrell precipitate and 4 percent ground cotton linters by weight were fed into the test duct in a concentration of about 1 gram of test dust per 1000 ft^3 of air. The pressure drop across the filter was measured as the dust load increased from zero to some arbitrary final value.

The lower curves in figure 1 show the increase in pressure drop as dust was fed to the filters. Both of the polyurethane filters developed more resistance for a given amount of dust than fiber glass. This was true whether results were based upon dust fed as shown in figure 1 or on dust retained by the filter. However the polyurethane foam had a lower initial pressure drop than the fiber glass which may partially help offset the greater tendency to become blocked by dust. If a pressure drop of 0.5 in. W.G. is arbitrarily selected as the upper pressure limit, a value which appears in Federal Standard FF-310a for viscous impingement filters, the fiber glass panel reached this pressure drop when 178 g of dust had been fed to the filter while only 98 g and 108 g of dust had been fed to the two polyurethane filters.

The results shown in the lower portion of figure 1 were obtained with an artificial dust which is somewhat coarser on the average than dust encountered in the post office. Therefore, dirty filters were brought back from the Philadelphia Post Office and panels were carefully cut from them and mounted in the test duct. Figure 2 shows the corresponding pressure drop across polyurethane and fiber glass filters at a series of increasing face velocities. The dirty polyurethane foam had a much higher resistance to air flow than the fiber glass. Dirt analysis showed the polyurethane had an average alcohol insoluble dirt content of 26 g per ft^2 while the average for the fiber glass was 24 g per ft^2. This difference is small compared with the rather large difference in resistance to air flow.

The lower dust holding capacity of polyurethane foam media in comparison with fiber glass is not a desirable feature. On the basis of these results it might be predicted that polyurethane foam would not last as long in service as fiber glass. However, this prediction was not fulfilled when polyurethane foam and fiber glass media were operated as roll filters, as is developed in the following sections of this report.

C. Filter Usage

a. Glass fiber usage, 1963 - 1968

The consumption of fiber glass media with which polyurethane usage is compared was obtained from records of the Plant Maintenance Department at the Philadelphia Post Office. The complete 1963 to 1968 record of filter changes and length of service between changes for all of the air handling units used in this study is summarized in table 4. The unit designations 1A, 1B in table 4 refer to units on the first floor, 2A, 2B, 2C, and 2D to units on the second floor, 3A, 3B, 3C, and 3D third floor, and 4A, 4B, 4C, and 4D to units on the fourth floor. WP-1 refers to a unit in the west penthouse, and EP-1, EP-2, etc. refer to units in the east penthouse. Penthouse units served largely office space on the fifth floor. Inspection of table 4 shows that there was wide variation in the length of service in each of the units. Also length of service in the penthouse units was consistently greater than on the lower floors.

It has been suggested that extremely long periods of service noted in the table might have been due to failure to record a filter change. However, rather than arbitrarily discard long periods of service, a frequency table has been set up in table 5, and where outlying values occur, as in units 1A, 1B, 2B, EP-1, and EP-9, these values are excluded from the average. Also certain values are noted in table 4 where all of the filters in the unit were not changed at the same time. These values have also been excluded from the average length of service in table 4. However, where these exclusions have been made, averages including all data are also given alongside in parentheses.

b. Comparison of polyurethane and glass fiber usage

The usage of filter media in each of the air handling units has been estimated by measuring the movement of marked filters. These measurements have been made weekly by a representative of Unifilter, Inc. They afford an estimate of filter usage since August 1968 when the filters were first installed. By January 17, 1969, when the last observation covered in this report was made, most of the filters had been in use 149 days or approximately 5 months. This is long enough to make projected estimates of filter usage for comparison with glass fiber data. In most of the units on the lower floors the polyurethane had exceeded the average length of service of fiber glass, and it may also last longer in most of the penthouse units by the time the test is complete.

From the amount of media remaining on the run-off rolls projected estimates of filter service has been made by means of the equation,

$$\text{Predicted length of service (days)} = \text{Length of service at last observation (days)} \times \frac{65}{\text{no. feet remaining on roll at last observation}} \qquad (2)$$

This method of projection assumes that future filter usage will take place at the same rate as during the first 5-months.

In table 6 predicted lengths of service of polyurethane filters in each of the units is listed along with average usage of glass fiber in the same units. Also in the last column of the table, recent 1967 - 1968 usage is tabulated. This was originally included with the idea that if there had been any gradual long term drift in the operating characteristics of the air handling units, recent data might be more comparable with polyurethane data than 5-year averages. Units 2A, 2B, and 2C are not included in the table, because they were special test units, and odd lengths filters and different methods of measurement were used. 2D is included only because one set of 65 ft. rolls ran through before it was taken over as a special test unit. In most cases the predicted length of service of polyurethane foam exceeds both the average length of service of fiber glass and the recent 1967-68 service. In about half of the units it exceeds the maximum recorded length of service for fiber glass.

When length of service in any given unit is examined, it is clear that usage data is quite variable in nature. However it is the total usage in all units which is of primary interest for cost estimates and the question arises as to how repeatable are total usage figures when individual lengths of service may vary widely. In table 7 a different estimate of glass fiber filter usage has been made. Only the first installation in each year is included. Data from subsequent installations in any given year is disregarded. Actually this may be more comparable with polyurethane data than overall averages, because polyurethane has only been installed once. It also gives an estimate of year-to-year variability of average length of service summed over all of the units. Considering the 5-years from 1963 through 1967 in this way, average length of service in all of the units in the table is 164 days with a standard deviation of 12 days. This is compared with an average length of service of 280 days for polyurethane.

The filters in units 2D, 3C, and EP-5 have run out, and this makes it possible to compare predicted and actual usage for these units, as has been done in table 8. In 3C the actual length of service was 11% less than the predicted value. If it is assumed that all of the predictions in table 6 are 11% too high, the average estimated length of service becomes 249 days instead of 280 days.

There is another factor which may make the estimate of polyurethane service slightly high in comparison with fiber glass. In normal usage the filters in a unit are changed when the run-off switch on one of the rolls signals that the diameter of the roll is less than a certain critical value. This value may vary somewhat from roll to roll. In this field trial with polyurethane foam the run-off switches were not used, and the filters were observed weekly. In this way it was possible to estimate rather closely when the filters were ready to run out. If it is arbitrarily assumed that the run-off switches call for a change when only 60 ft. from each roll has been used on the average, a revised estimate of $164 \times \frac{65}{60} = 177$ days would be obtained for the average length of service of fiber glass. This is still shorter service than was obtained with polyurethane foam, and it leads to the conclusion that in spite of its lower dust holding capacity, polyurethane foam promises to significantly outlast fiber glass when tested as roll filters at the Philadelphia Post Office.

c. Spot check of Unifilter's usage estimates

As previously mentioned the consumption of polyurethane foam media was based upon Unifilter's weekly measurement of the movement of marked filters. An independent check of this estimate was made by measuring the diameters of the run-off rolls. These diameters were converted to lengths by comparison with length vs. diameter data obtained from an actual roll prepared at the plant.

A comparison of these estimates of usage is given in table 9. This comparison is based on data collected in December, after 121 days of service. All of the filters in an air handling unit did not run through at the same rate. Sometimes this difference was significant. This is shown in the usage estimates based on diameter measurements in table 9. The Unifilter estimates, on the other hand, were based on movement of a single filter in each unit. Nevertheless, estimates of total usage by the two methods shown at the bottom of table 9 agree within 2 percent, even though Unifilter's estimates were based on a single filter in each unit, and even though variations between rolls in a single unit might vary by as much as several feet in a few units. Agreement was still closer when the comparison was limited to the same individual filters rather than the entire unit. From this it is concluded that Unifilter's estimates of total filter usage do not greatly overestimate or underestimate filter usage.

d. Usage in special test units

The determination of relative filter usage by the direct comparison of polyurethane and fiber glass in the test units was less conclusive than anticipated, because the selection of two closely matched units proved difficult. Initially, polyurethane was installed in unit 2B and fiber glass in 2A. In this test polyurethane was consumed much more rapidly than fiber glass. In the next comparison polyurethane was installed in 2A and fiber glass in 2B. This time the fiber glass ran through more rapidly. In other words more media, regardless of type, was used in unit 2B than in 2A. This is summarized in table 10.

The downstream faces of the filters were scanned with a vane annemometer to obtain comparative air velocities. The average face velocity in 2B was greater than in 2A. These data are also given in table 10. Of perhaps even greater importance, there was also more turbulence in 2B than in 2A, which was reflected in fluctuations of the pressure across the filter.

The comparison of the two media was then shifted to units 2C and 2D. Here the fiber glass advanced more rapidly than the polyurethane but average velocity was also greater in the fiber glass unit, particularly after the fan belts were changed. These data are summarized in table 11.

The test units have proven useful for arrestance comparisons and comparative air velocity measurements, but the comparison of filter usage was less conclusive than it would have been if the units were more closely matched.

e. Examination of some factors influencing filter usage

The pressure drop as a function of air velocity, as shown in figure 2, and usage and air velocity measurements in tables 10 and 11 suggest that air velocity should be an important factor influencing the rate of filter consumption. An estimate of relative air velocity in each of the units at the post office was made by vane anemometer measurements near the center point of each filter about 1 1/2 inches from the downstream face. In figure 5 predicted length of service of polyurethane foam is plotted against relative face velocity. A nearly random relationship is obtained. However, if the number of points is divided in half vertically and horizontally, the field is divided into four quadrants. More than half of the points fall into the upper left or lower right quadrant, which conforms in a general way with the expected relationship between length of service and air velocity. However, this is a very weak correlation considering the large effect of air velocity on pressure drop, as shown in figure 2 for example. An analysis based on relative air velocities measured at the fan inlets led to a similar scatter of points. The poor correlation between air velocity and rate of filter consumption indicates that other factors play an important part in determining filter consumption.

Another factor which is believed to influence filter usage is the settings of the pressure switches which control the movement of media. Table 12 lists the pressure switch settings which were measured in the air handling units at the Philadelphia Post Office. The values were obtained by connecting a slope gage to the high pressure side of each switch and slowly raising or lowering the pressure until the switch responded.

In figure 5 actuating (upper) pressures and difference between actuating and deactuating pressures have been averaged from data in each quadrant, and the averages are given in the figure. The average actuating pressure of 0.57 in. W.G. for the upper left quadrant includes unit WP-1 which had an abnormally high setting of 1.07 in. W.G. When this value is deleted, the average for the quadrant is 0.45 in. W.G. which is comparable with the values in the other quadrants. Thus there appears to be very little correlation between length of service and pressure switch settings. The upper right and lower left quadrants in figure 5 are of particular interest. The upper right represents units where filter service was longer than predicted from air velocity measurements, and the lower left units where service was shorter. The average actuating pressure for the upper right is less than it is for the lower left quadrant. This observation has been repeated with data obtained with fiber glass, and it casts doubt on the widely held view that raising the actuating pressure of the switch increases length of filter service.

f. Airborne dust concentration and filter usage

It goes without saying that the concentration and nature of airborne dust is an important factor influencing filter usage. The removal of airborne dust is the sole purpose of air filters. However, in the comparison of filter media or the comparison of filtration at different locations, it is systematic differences in dust level rather than absolute concentrations which are of primary importance. There are no long term data on comparative dust levels in all of the filter units at the Philadelphia Post Office, however, the dust spot measurements in table 3 indicate that, except for August, the comparative dust levels in the units examined were nearly equal. In November, 16 hour comparisons of unit 4d on the 4th floor and 2c on the second floor also indicated only small differences. It would require differences greater than those shown in table 3 to account 3 to 1 differences in length of service in individual units or between units as shown in table 4.

Systematic differences in dust level were observed during the four visits to the Philadelphia Post Office. These are shown in figure 6 where dust levels for each hour of the day have been averaged to obtain composite 24-hour trends. An empirical factor was used to permit comparison of 2 hour spot data with 1 hour data. The highest average dust levels were observed in August and the lowest in November. This may be related to the comparative amounts of return air used by ventilating systems because the amount of return air was high in August and low in November. It did not seem to be strongly related to the volume of mail handled, because mail volume was higher in this particular vicinity in November than in any of the other periods covered, including the week before Christmas.

It is doubtful if differences in dust level such as those shown in table 3 or in figure 6 would account for the poor correlation between filter usage and air velocity shown in figure 5. However analysis of insoluble dirt in a filter produces some interesting results. In figure 7 insoluble dirt content is plotted as a function of distance from the terminal end of the filter for three filters which were in unit 2B from September 23 through November 14. These analyses are based upon samples taken at selected points along the center line of each filter. Three inch circles were carefully cut from the filters, and the dirt was removed with alcohol. Most of the dirt was insoluble, and this part was determined gravimetrically. There are wide differences in the amount of dirt at different positions along the length of the filters, and in most cases the three filters show similar ups and downs at corresponding positions. These differences are greater than would be expected if the movement of filter media were a simple orderly process controlled by the gradual accumulation of dirt until a pressure drop is reached at which the pressure switch is actuated. They suggest that the filters may have been moved before they had a chance to collect their full capacity of dirt, and that some random factors affected the movement of the filters.

g. Random factors influencing filter usage

Some suggested random effects which might trigger movement of media are turbulence due to high Reynolds' numbers, gusts of wind through the outside dampers, and rapid opening of dampers in response to demands by the ventilating system. There may also be delayed response and inertial effects which allow the media to continue in motion after the cut-off setting of the switch has been passed. For example filter movement in unit 2B was once observed to start because of a transient rise in pressure when the "steady state" pressure was 0.46 to 0.48 in. W.G., and movement continued until a value fluctuating between 0.36 and 0.40 in. W.G. was reached. These are quite different from the settings of the pressure switch shown in table 12. If random movements such as these play an important part in filter movement, there may be considerable waste of media. This also suggests one possible mechanism by which polyurethane outlasts fiber glass. A random signal would probably produce less movement of polyurethane because of its thinner structure and smaller take up rolls than in the case of fiber glass.

D. Cost

Table 13 gives an itemized breakdown of the estimated cost of installing polyurethane and fiber glass filter media in the air handling units in the Main Post Office at Philadelphia. Units 4C and 4D are included in this cost breakdown even though they are not operating as roll filters at the present time. The price of individual filters upon which table 13 is based is given in table 14 along with the source of the information.

With polyurethane filters the price includes the rental of the filter and the cost of installation. With fiber glass the price includes purchase of the filter. Installation is left to the user. There is some latitude in the estimate of installation cost, and the values in table 13 are based upon an estimate supplied by Mr. James Foster of Unifilter, according to which, 1/2 man hour is required to change a single filter. For a 3-filter unit this corresponds to 1 1/2 man hours. Post office maintenance personnel estimate that it takes 2-hours for two men to change a unit, or 4-man hours. Actually Unifilter was allowed $5 per filter in the service contract, which is comparable with post office maintenance estimates.

An analysis of ten typical filter changes and the PFS grade of the personnel making the changes is made in table 15, and an average hourly rate of $3.78 is estimated. This is roughly the rate of a PFS-6. The hourly rates for each grade has been calculated from the annual rate as indicated at the bottom of table 16. The foregoing estimate includes only direct salary cost and does not include any kind of overhead. From the breakdown in table 13, the cost of installing polyurethane in all of the units is $1992.00, while the cost of installing fiber glass is $1665.42. If 4-man hours instead of 1 1/2 man hours is required to install a 3-filter unit, the total cost of installation would be, $\$119.07 \times \frac{4}{1.5} = 317.52$. This would make the total cost of installing glass fiber filters $1863.87.

The annual cost of operating filters may be calculated from the following relationship,

$$\text{Annual cost} = \text{Total cost of installation} \times \frac{365}{\text{average number of days total filter service per installation}} \quad (3)$$

If 249 days is taken as the average length of service for polyurethane and 177 days for fiber glass, estimates which have been developed in the discussion of table 7, the following annual costs are obtained from equation 3,

$$\text{Annual cost of polyurethane} = \$1992 \times \frac{365}{249} = \$2910$$

$$\text{Annual cost of fiber glass} = \$1665 \times \frac{365}{177} = \$3430.$$

If 12 days, given in table 7, is a good estimate of the standard deviation of average service per unit, based on usage summed over all of the units, this corresponds to a repeatability of $\pm$ $210 to $250 in the estimates of annual cost, provided the same assumptions are made in developing the estimates.

The cost of polyurethane is based on 149 days service. A somewhat closer estimate can be made when all of the filters have completed their service.

E. Acknowledgment

The author wishes to acknowledge the invaluable assistance of Mr. L. A. Tomes and Mr. B. L. Shomaker in obtaining data shown in the figures and graphs of this report, in developing the procedure for determining the dirt content of a filter, and in the design and construction of accessories used in this work.

F. TABLES

Table 1

Initial arrestance of polyurethane and fiber glass filters using atmospheric dust at Gaithersburg

Arrestance (percent)		
Polyurethane		Fiber glass
1st filter	2nd Filter	
6.3	-2.0	-4.0
11.6	0	1.5
-	0	
-	0.7	
24.2[1]	6.8	

1. Two arrestance determinations between this value and the preceding one were discarded because of malfunction of one of the holders.

Table 2

Comparison of average dust spot arrestances of fiber glass and polyurethane foam filters in operation at the Philadelphia Main Post Office

	Time per spot (hours)	Filter	Average dust spot arrestance (percent)* Glass (in unit 2A)	No. Spots	Polyurethane (in unit 2B)	No. Spot
Aug. 21-22	2	A	45 ± 7	10	33 ± 17	12
22-23	2	B	38 ± 6	10	29 ± 4	10
23-24	2	C	53 ± 5	11	43 ± 6	10
			Glass (in unit 2B)		Polyurethane (in unit 2A)	
Oct. 8-9	2	A	32 ± 7	11	24 ± 6	11
9-10	1	B	17 ± 10	24	22 ± 8	26
10-11	1	C	24 ± 6	15	22 ± 6	14
11-12	1	A	24 ± 10	15	28 ± 6	16
			Glass (in unit 2D)		Polyurethane (in unit 2C)	
Nov. 20-21	1	A	16 ± 12	23	14 ± 8	21
21-22	1	C			21 ± 7	17
Dec. 18-19	1	A	17 ± 7	15	19 ± 7	15
19-20	1	C	14 ± 6	22	13 ± 3	21

* The measure of dispersion is the standard deviation of individual arrestance values about the average value.

Table 3

Comparison of upstream dirt concentration in test units 2A, 2B, 2C and 2D

	Time per spot (hours)	Average Optical Density of Dust Spots		
		Unit 2A (Fiber glass)	Unit 2B (Polyurethane Foam)	Ratio $\frac{2A}{2B}$
Aug. 21-22	2	0.699	0.499	1.412
22-23	2	.794	.566	1.403
23-24	2	.757	.574	1.378
		Unit 2A (Polyurethane)	Unit 2B (Fiber glass)	
Oct. 8-9	2	0.405	0.446	0.908
9-10	1	.245	.257	.953
10-11	1	.222	.261	.851
11-12	1	.315	.330	.955
		Unit 2C (Polyurethane)	Unit 2D (Fiber glass)	Ratio $\frac{2C}{2D}$
Nov. 20-21	1	.238	.222	1.072
21-22	1	.259	.231	1.121
Dec. 18-19	1	.366	.365	1.003
19-20	1	.436	.426	1.023

Table 4

Tabulation of filter changes at the Philadelphia Post Office for the years 1963-1968

Unit 1A		Unit 1B		Unit 2A	
Date Changed	Length of Service (days)	Date Changed	Length of Service (days)	Date Changed	Length of Service (days)
5-27-63		5-3-63		5-27-63	
8-7-63	72	8-7-63	96	7-22-63	56
12-26-63	141	12-26-63	141	9-27-63	67
5-27-64	153	6-11-64	168	1-9-64	104
4-24-65	332[2]	9-10-64	91	4-24-64	106
8-31-65	129	10-12-64	32	9-15-64	144
1-17-66	139	12-22-64	71	10-12-64	27
6-22-66	156	4-29-65	128	2-9-65	120
10-17-66	117	7-20-65	82	6-10-65	121
4-14-67	179	10-19-65	91	8-24-65	75
8-1-67	109	7-10-66	264[2]	2-25-66	185
11-27-67	118	10-17-66	99	7-4-66	129
3-4-68	98	3-20-67	154	10-5-66	93
		8-1-67		3-23-67	169
		11-27-67	252[1]	8-21-67	151
				12-15-67	116
				1-24-68	
				5-13-68	150[1]
Average	128 (145)		105 (128)		111 (113)

1. These values represent cases where all of the filters in the unit were not changed at the same time. They are only included in averages shown in parentheses.

2. These values represent discontinuities in the distribution, and are only included in the averages shown in parentheses.

Table 4 (continued)

Unit 2B		Unit 2C		Unit 2D	
Date Changed	Length of Service (days)	Date Changed	Length of Service (days)	Date Changed	Length of Service (days)
7-15-63		6-30-63		5-6-63	
9-6-63	53	8-28-63	59	7-27-63	82
1-3-64	119	2-1-64	157	9-25-63	60
3-26-64	83	6-12-64	132	1-3-64	100
6-20-64	55	12-19-64	190	5-21-64	139
9-21-64	124	5-28-65	160	9-10-64	112
11-9-64	49	8-9-65	73	2-9-65	152
3-2-65	113	10-12-65	64	9-29-65	232
7-2-65	122	3-23-66	163	1-17-66	110
9-29-65	89	9-2-66	163	6-22-66	156
12-27-65	89	3-3-67	182	1-24-67	216
7-4-66	189	5-27-67	85	6-9-67	136
3-16-67	255[2]	7-25-67	59	8-24-67	76
6-2-67	78	9-11-67	48	11-8-67	
7-14-67	42	11-8-67	58	12-13-67	111[1]
8-21-67	38	3-4-67	117	1-23-68	41[1]
1-24-68	156	6-24-68	112	5-10-68	108
5-10-68	107			6-10-68	31
6-24-68	45			7-30-68	50
Average	91 (100)		114		117 (112)

Table 4 (continued)

Unit 3A		Unit 3B		Unit 3C	
Date Changed	Length of Service (days)	Date Changed	Length of Service (days)	Date Changed	Length of Service (days)
7-6-63		6-12-63		8-6-63	
12-3-63	150	7-9-63	27	12-2-63	118
4-29-64	148	12-2-63	146	5-23-64	173
7-29-64	91	4-12-64	132	8-12-64	81
12-22-64	146	7-20-64	99	12-23-64	133
4-8-65	107	11-11-64	114	3-4-65	81
8-31-65	145	2-12-65	93	7-18-65	126
1-5-66	127	8-5-65	174	10-21-65	95
5-26-66	141	3-9-66	216	2-22-66	124
8-30-66	96	9-2-66	177	5-6-66	73
1-18-67	141	11-29-66	88	8-30-66	116
5-18-67	120	5-19-67	171	11-28-66	90
8-21-67	95	8-21-67	94	1-18-67	51
11-20-67	91	12-18-67	119	3-16-67	57
3-4-68	105	4-5-68	109	6-2-67	78
7-30-68	148	5-10-68	35	8-24-67	83
				11-27-67	95
				2-27-68	
				6-11-68	197[1]
Average	123		120		98 (104)

Table 4 (continued)

Unit 3D		Unit 4A		Unit 4B	
Date Changed	Length of Service (days)	Date Changed	Length of Service (days)	Date Changed	Length of Service (days)
7-2-63		5-6-63		9-6-63	
9-9-63	69	8-28-63	114	3-15-64	191
2-12-64	156	10-11-63	44	7-6-64	113
5-30-64	108	12-23-63	73	10-18-64	104
8-13-64	75	5-21-64	150	3-3-65	136
10-17-64	65	9-10-64	112	7-31-65	150
11-11-64	25	1-29-65	141	10-28-65	89
2-2-65	83	7-21-65	173	1-25-66	89
4-7-65	64	11-13-65	115	6-9-66	135
7-21-65	105	2-22-66	101	8-23-66	75
10-21-65	92	6-20-66	118	3-16-67	205
2-7-66	109	10-5-66	107	6-14-67	90
7-13-66	156	2-9-67	127	8-18-67	65
9-23-66	72	6-1-67	112	11-2-67	76
1-24-67	123	8-24-67	84	4-5-68	155
5-18-67	114	12-13-67			
8-24-67	98	12-15-67	112[1]		
12-22-67	120	5-22-68	160[1]		
5-10-68	140				
Average	99		112 (115)		120

Table 4 (continued)

Unit WP-1		Unit EP-1		Unit EP-2	
Date Changed	Length of Service (days)	Date Changed	Length of Service (days)	Date Changed	Length of Service (days)
8-7-63		5-13-63		6-25-63	
6-6-64	304	11-19-63	190	5-26-64	335
6-15-65	374	5-24-64	188	5-13-65	353
3-8-66	266	2-1-65	252	2-25-66	288
8-11-66	156	7-6-65	155	9-2-66	189
4-11-67	243	10-27-65	113	5-22-67	262
10-6-67	178	8-11-66	288	1-24-68	247
4-3-68	180	3-2-67	203	8-2-68	191
		4-4-67	33[2]		
		7-14-67	101		
		12-13-67	152		
Average	243		182 (168)		266

Table 4 (continued)

Unit EP-3		Unit EP-4		Unit EP-5	
Date Changed	Length of Service (days)	Date Changed	Length of Service (days)	Date Changed	Length of Service (days)
9-9-63		2-10-64		6-25-63	
6-6-64		11-10-64	274	2-10-64	259
8-3-64	329[1]	9-13-65	307	9-11-64	185
4-9-65	249[1]	5-2-66	231	5-11-65	242
11-14-65	219	1-16-67	259	10-28-65	170
5-17-66	184	9-12-67	239	4-17-66	171
2-9-67	268	5-24-68	255	3-7-67	224
6-1-67	112			7-13-67	128
2-13-67				12-13-67	153
2-26-68	270[1]			5-3-68	142
Average	196 (233)		261		186

Table 4 (continued

Unit EP-6		Unit EP-7		Unit EP-8	
Date Changed	Length of Service (days)	Date Changed	Length of Service (days)	Date Changed	Length of Service (days)
7-15-63		7-15-63		9-6-63	
4-23-64	283	4-24-64	284	3-10-64	186
11-10-64	201	11-6-64	196	9-11-64	185
6-10-65	212	5-28-65	203	10-11-65	395
12-27-65	200	2-2-66	250	6-9-66	241
5-17-66	141	8-30-66	209	1-16-67	221
1-16-67	244	2-24-67	178	8-24-67	220
8-24-67	220	8-30-67	187	6-10-68	291
8-1-68	343	5-20-68	264		
Average	231		221		248

Table 4 (continued)

Unit EP-9

Date Changed	Length of Service (days)
12-3-63	
6-8-64	188
1-4-65	210
8-10-65	218
10-16-66	432[2]
2-9-67	116
7-20-67	161
2-10-68	205
7-24-68	165
Average	180 (212)

Table 5

Frequency distribution of length of filter service in air handling units

Length of Service (days)	Frequency																					
	1A	1B	2A	2B	2C	2D	3A	3B	3C	3D	4A	4B	WP 1	EP 1	EP 2	EP 3	EP 4	EP 5	EP 6	EP 7	EP 8	EP 9
<50		1	1	4	1	2		2		1	1			1								
51-100	2	6	4	6	6	4	4	4	10	8	3	6										
101-150	6	2	8	5	3	5	11	5	5	7	9	5		2		1		2	1			1
151-200	3	2	3	2	6	2		3	1	2	1	2	3	4	2	1		4	1	3	2	5
201-250						2		1				1	1	1	1	1	2	2	4	3	2	1
251-300		2		1									1	2	2	1	3	1	1	2	1	
>300	1												2		2		1		1		1	1

Table 6

Comparison of length of service of polyurethane foam and glass fiber filters in the Philadelphia Post Office

	Length of Service (Days)		
		Fiber Glass	
Unit	Polyurethane (Predicted)	1963-68 Average	Recent 1967-68
1A	204	128	98
1B	207	105	154
2D	63	117	50
3A	232	123	148
3B	255	120	35
3C	149	98	95
3D	204	99	140
4A	205	112	84
4B	200	120	155
WP-1	410	243	180
EP-1	319	182	152
EP-2	307	266	191
EP-3	359	196	112
EP-4	532	261	255
EP-5	168	186	142
EP-6	348	231	343
EP-7	538	221	264
EP-8	296	248	291
EP-9	331	180	165
Average	280	170	161

Table 7

Comparison of length of service of fiber glass and polyurethane, considering the first installation in each year

	Length of service of fiber glass						1968 Length of Service Polyurethane (est.)
	1963	1964	1965	1966	1967	Average	
1A	72		129	156	109	117	204
1B	96	91	82	99		92	207
2A	56	106	121	129	151	113	
2B	53	83	122	255	78	118	
2C	59	132	73	182	85	106	
2D	82	139	232	156	136	149	63
3A	150	91	145	141	120	129	232
3B	27	99	174	177	94	114	255
3C	118	81	126	73	57	91	149
3D	69	108	64	156	114	102	204
4A	114	112	173	118	112	126	205
4B	191	104	150	135	90	134	200
4C							
4D							
WP-1	304	374	266	156	178	256	410
EP-1	190	252	155	203		200	319
EP-2	335	353	288	189	247	282	307
EP-3			219	268	112	200	359
EP-4		274	231	259	239	251	532
EP-5	259	185	170	224	128	193	168
EP-6	383	201	200	244	220	250	348
EP-7	284	196	250	209	187	225	538
EP-8	186	185	241	221	220	211	296
EP-9	188	210		116	161	169	331
Average	161	169	172	176	142	165	280

Grand average glass fiber 164 ± 12

Table 8

Comparison of predicted and actual filter use

		Length of Service (days)		
Unit	When predicted (days)	Predicted	Actual	Difference
2D	51	63	61	2
3C	121	149	133	16
EP-5	121	168	153	15

Table 9

Comparison of estimates of filter usage from measurement of movement of marks and from measurement of diameter of rolls after filters were in service 121 days

Unit	From Diameter of Run-Off Roll			Average	From Movement of Marks
	A	B	C		
1A	30.0	23.3	20.5*	24.6	31.7
1B	53.5*	51.0	19.0	41.2	38.2
3A	42.0	41.0	41.0*	41.3	37.3
3B	32.0*	28.0	30.0	30.0	30.2
3C	56.5*	60.0	52.2	56.2	52.7
3D	36.0*	31.0	39.6	35.5	36.8
4A	36.0	43.0*		39.5	42.1
4B	45.0	44.0	42.0*	43.7	42.3
WP-1	14.5	14.5	14.5*	14.5	19.4
EP-1	Rolls inaccessible to calipers				
EP-2	26.0*	31.0		28.5	26.2
EP-3	15.5	14.7	16.5*	15.6	21.0
EP-4	14.8*	27.5		21.2	14.7
EP-5	47.8	52.8*		50.3	46.7
EP-6	26.5*	25.2		25.9	23.0
EP-7	10.5	7.0	14.6*	10.7	14.5
EP-8	23.0*	27.5		25.3	27.9
EP-9	15.5*	21.0		18.3	24.5
Total	528.7*			522.3	529.2

* These values are based on caliper measurements of same marked rolls which are tabulated in the right hand column.

Table 10

Filter Usage in test units 2A and 2B

	Unit	Average face velocity (ft/min)	Average usage Polyurethane (ft)	Unit	Average face velocity (ft/min)	Average Usage Glass fiber (ft)
Aug. 15 - Sept. 26	2B	505	30	2A	311	13
Sept. 23 - Nov. 24	2A	387	9	2B	526	32

Table 11

Filter Usage in test units 2C and 2D

	Unit	Average face velocity (ft/min)	Average usage Polyurethane (in.)	Unit	Average face velocity (ft/min)	Average Usage Glass fiber (in.)
Nov. 19 - Dec. 18	2C	395	94	2D	476	97
Dec. 19 - Dec. 27	2C	477	49	2D	704*	>75

* The fan belts replaced and tightened just before these measurements were made, and this produced a significant increase in air velocity.

Table 12

Pressure switch settings[1,2]

	Upper Pressure (in. W.G.)	Lower Pressure (in. W.G.)	Difference (in. W.G.)	Readjusted Settings Upper Pressure (in. W.G.)	Readjusted Settings Lower Pressure (in. W.G.)	Readjusted Settings Difference
1A	0.52	0.47	0.05			
1B	.56	.49	.07			
2A	.40	.33	.07	.50	.45	.05
2B	.40	.37	.03	.50	.46	.04
2C	.56	.52	.04	.50	.46	.04
2D	.44	.40	.04	.50	.46	.04
3A	.44	.40	.04			
3B	.51	.46	.05			
3C	.43	.38	.05			
3D	.54	.49	.05			
4A	.46	.41	.05			
4B	.40	.35	.05			
WP-1	1.03	.96	.07			
EP-1	.58	.53	.05			
EP-2	.47	.43	.05			
EP-3	.45	.39	.07			
EP-4	.47	.41	.06			
EP-5	.45	.40	.05			
EP-6	.47	.41	.06			
EP-7	.39	.33	.06			
EP-8	.51	.44	.07			
EP-9	.44	.38	.06			

1 All initial pressure switch settings were measured August 21-22, 1968, except those in 1A & 1B which were measured October 9-10, 1968.

2 in. W.G. = inches water gage.

Table 13

Comparative cost of placing polyurethane or glass fiber in each of the air handling units at the Philadelphia Post Office

	No. & Size Filters			Polyurethane			Fiber Glass		
	3 ft.	4 ft.	5 ft.	Cost of Media	Cost of Installation	Total Cost	Cost of Media	Cost of Installation	Total Cost
1A		3		$96.00	Cost of installation included in purchase price	$96.00	$74.70	$5.67	$80.37
1B		3		96.00		96.00	74.70	5.67	80.37
2A		3		96.00		96.00	74.70	5.67	80.37
2B		3		96.00		96.00	74.70	5.67	80.37
2C		3		96.00		96.00	74.70	5.67	80.37
2D		3		96.00		96.00	74.70	5.67	80.37
3A		3		96.00		96.00	74.70	5.67	80.37
3B		3		96.00		96.00	74.70	5.67	80.37
3C		3		96.00		96.00	74.70	5.67	80.37
3D		3		96.00		96.00	74.70	5.67	80.37
4A		1	1	66.50		66.50	54.00	3.78	57.78
4B		3		96.00		96.00	74.70	5.67	80.37
4C		3[1]		96.00[1]		96.00[1]	74.70[1]	5.67[1]	80.37[1]
4D		3[1]		96.00[1]		96.00[1]	74.70[1]	5.67[1]	80.37[1]
WP-1		3		96.00		96.00	74.70	5.67	80.37
EP-1		1		32.00		32.00	24.90	1.89	26.79
EP-2	1	1		58.20		58.20	43.65	3.78	47.43
EP-3		3		96.00		96.00	74.70	5.67	80.37
EP-4	1	1		58.20		58.20	43.65	3.78	47.43
EP-5	1	1		58.20		58.20	43.65	3.78	47.43
EP-6	1	1		58.20		58.20	43.65	3.78	47.43
EP-7		3		96.00		96.00	74.70	5.67	80.37
EP-8	1	1		58.20		58.20	43.65	3.78	47.43
EP-9		1	1	66.50		66.50	54.00	3.78	57.78
Total	5	56	2	1992.00		1992.00	1546.35	119.07	1665.42

1. These units are not operating as roll filter units at the present time.

Table 14

Cost per 65 ft. roll of polyurethane and fiber glass media

Nominal Width of Roll	Polyurethane	Source	Glass Fiber	Source
3 ft.	$26.20	Letter of March 7, 1968, from Mr. Frank L. Eisenhower of Unifilter to Mr. Henry E. Robinson of the National Bureau of Standards	18.75	Memorandum of March 14, 1968 from J. H. Lucas to Director of Office of Plant Maintenance, Philadelphia Post Office
4 ft.	32.00		24.90	
5 ft.	34.50		29.10	

Table 15

Analysis of ten typical filter changes and estimate of average hourly labor cost

Change No.	PFS Grade of Employees			Hourly Rate		
1	6	5		$3.71	$3.47	
2	5	8		3.47	4.26	
3	5	8		3.47	4.26	
4	5	5		3.47	3.47	
5	5	8		3.47	4.26	
6	6	5		3.71	3.47	
7	8	6		4.26	3.71	
8	5	8		3.47	4.26	
9	6	5	8	3.71	3.47	4.26
10	5	8		3.47	4.26	

Average hourly rate $3.78

Table 16

Annual and estimated hourly rate of filter change personnel

PFS Grade	Annual Salary	Estimated[1] Hourly Rate
5	$5938	3.47
6	6348	3.71
7	6807	3.91
8	7286	4.26

1 This rate is estimated from the formula, Hourly rate = $\frac{\text{annual salary}}{2080 - 368}$, where 2080 are the total number of working hours in a year, and 368 is estimated number of hours allotted for annual leave, sick leave, and holidays.

G. GRAPHS

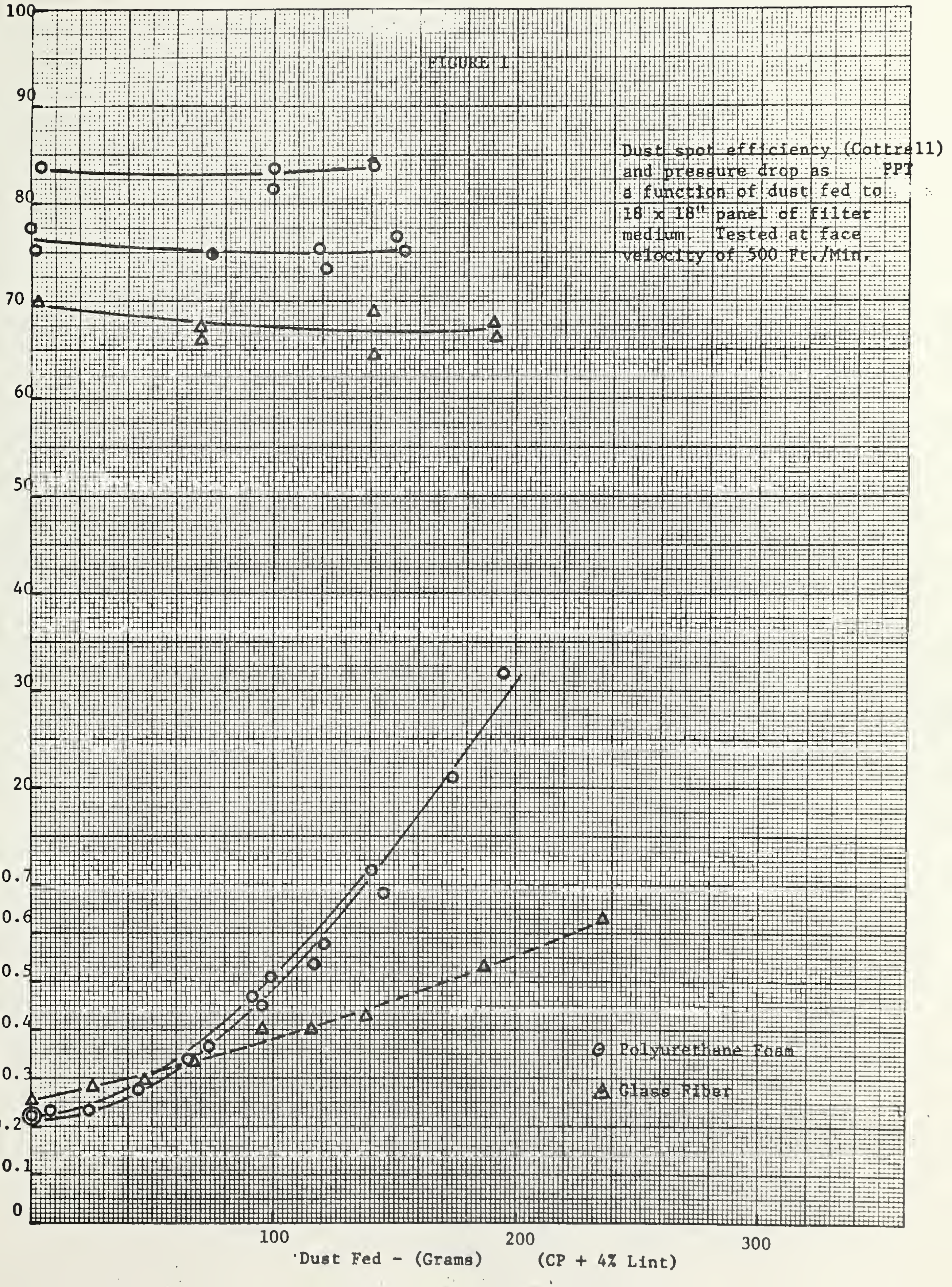


FIGURE 1
Dust spot efficiency (Cottrell) and pressure drop as a function of dust fed to 18 x 18" panel of filter medium. Tested at face velocity of 500 Ft./Min.
PPI
Polyurethane Foam
Glass Fiber
100
90
80
70
60
50
40
30
20
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
100
200
300
Dust Fed - (Grams)
(CP + 4% Lint)

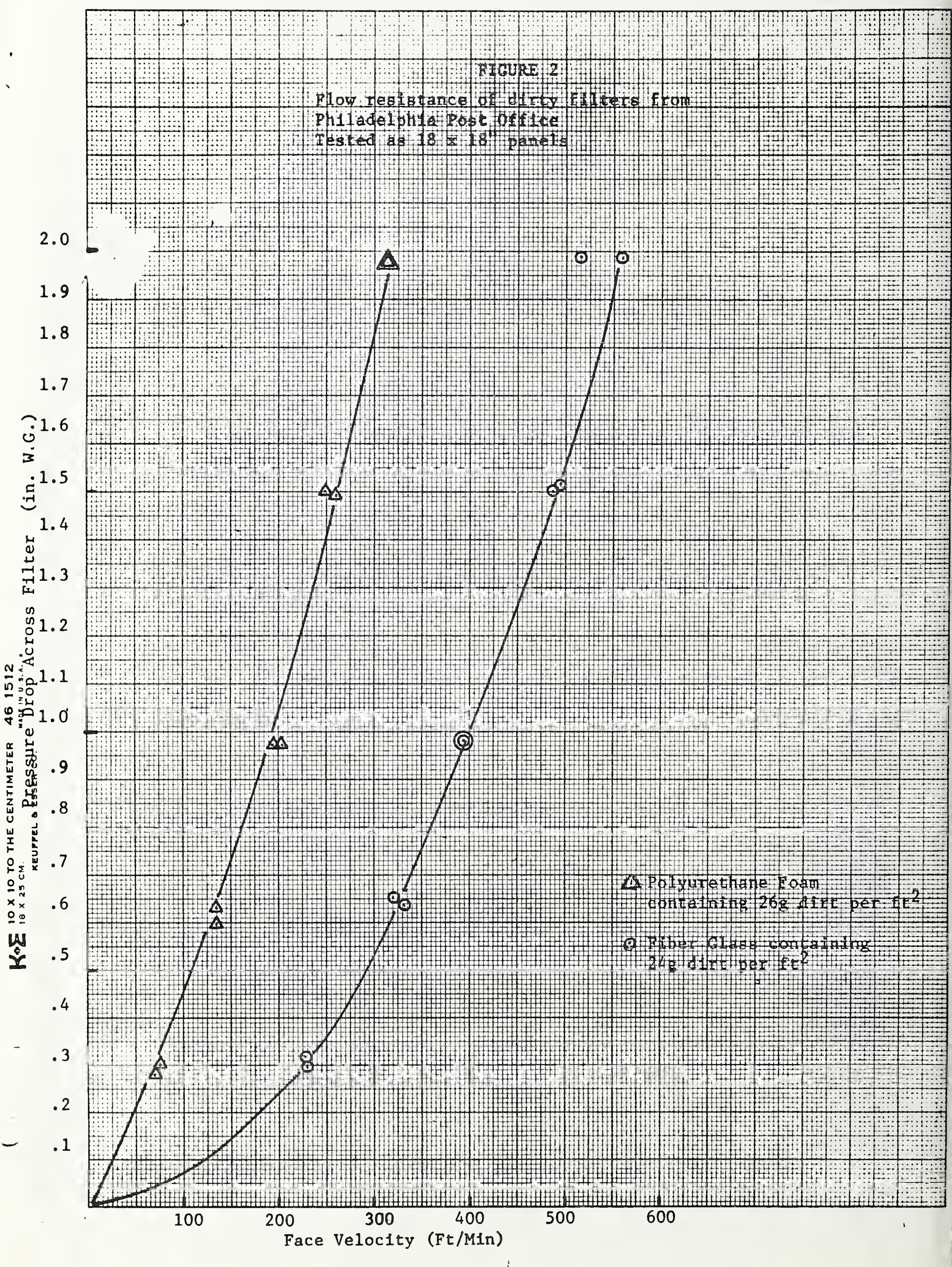


FIGURE 2
Flow resistance of dirty filters from
Philadelphia Post Office
Tested as 18 x 18" panels
Pressure Drop Across Filter (in. W.G.)
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
100
200
300
400
500
600
Face Velocity (Ft/Min)
Polyurethane Foam containing 26g dirt per ft²
Fiber Glass containing 24g dirt per ft²
K+E 10 X 10 TO THE CENTIMETER 46 1512
18 X 25 CM. MADE IN U.S.A.
KEUFFEL & ESSER CO.

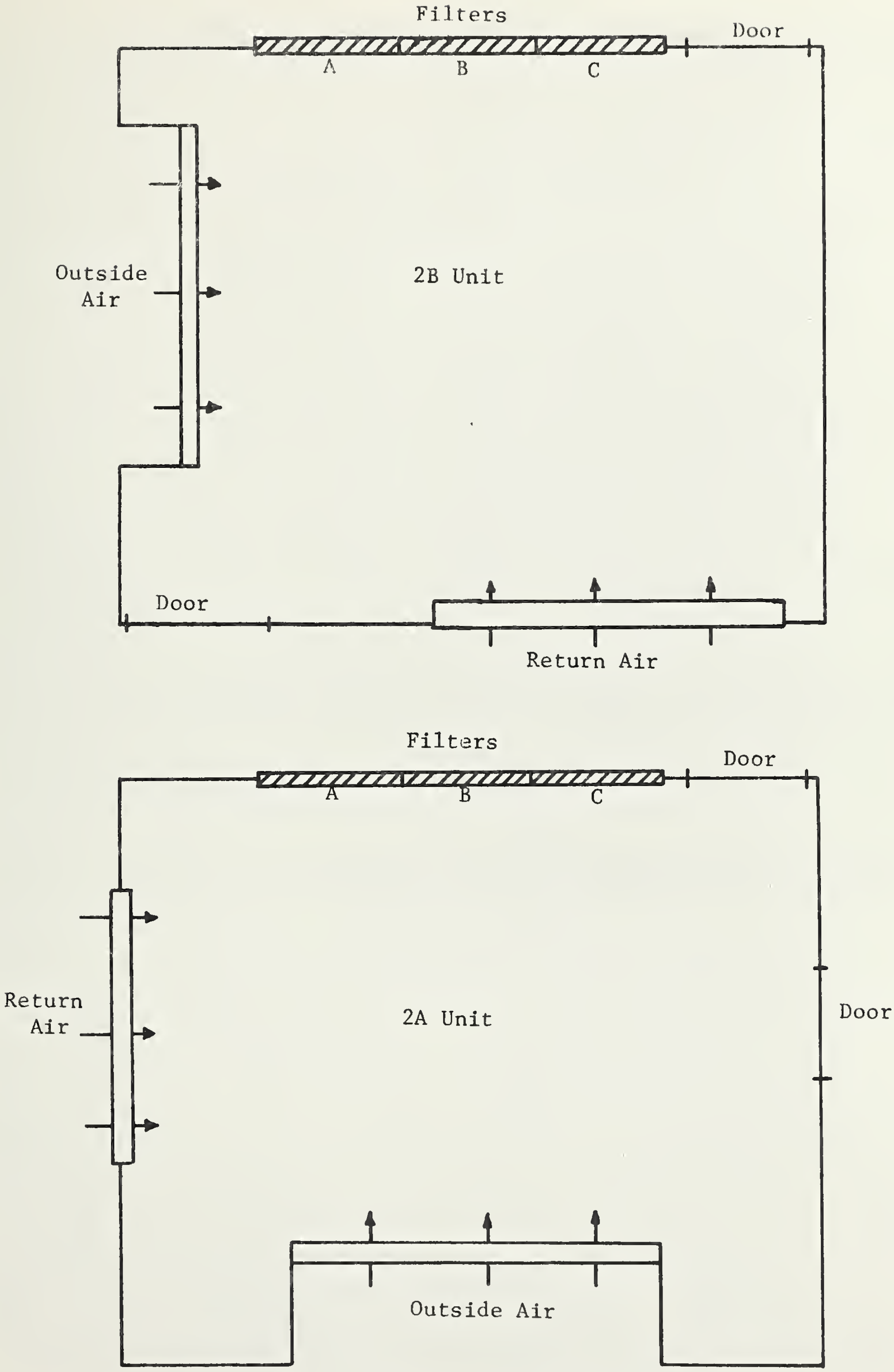


Diagram of Upstream
Compartments of Test
Units 2A and 2B

FIGURE 3

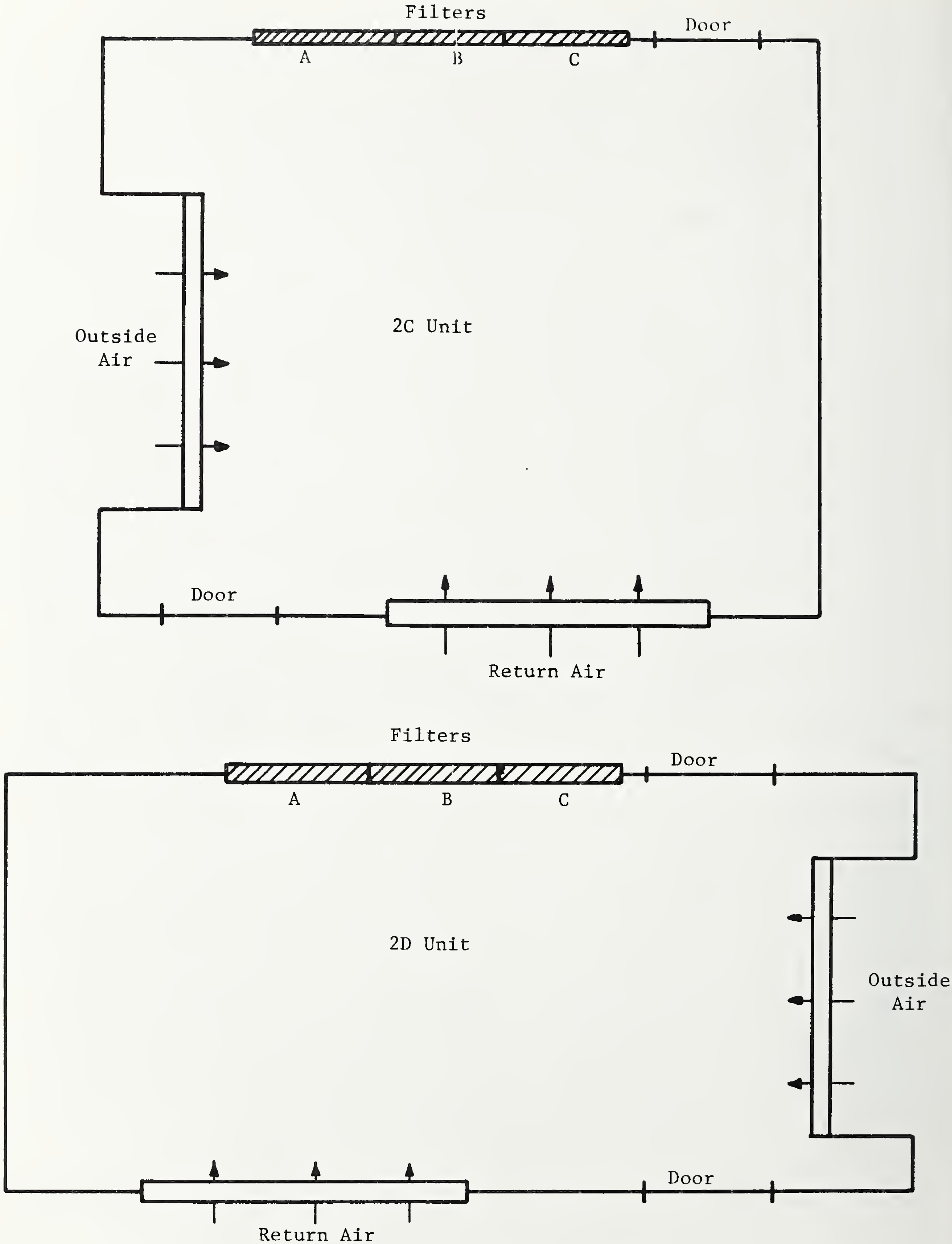


Diagram of Upstream
Compartments of Test
Units 2C and 2D

FIGURE 4

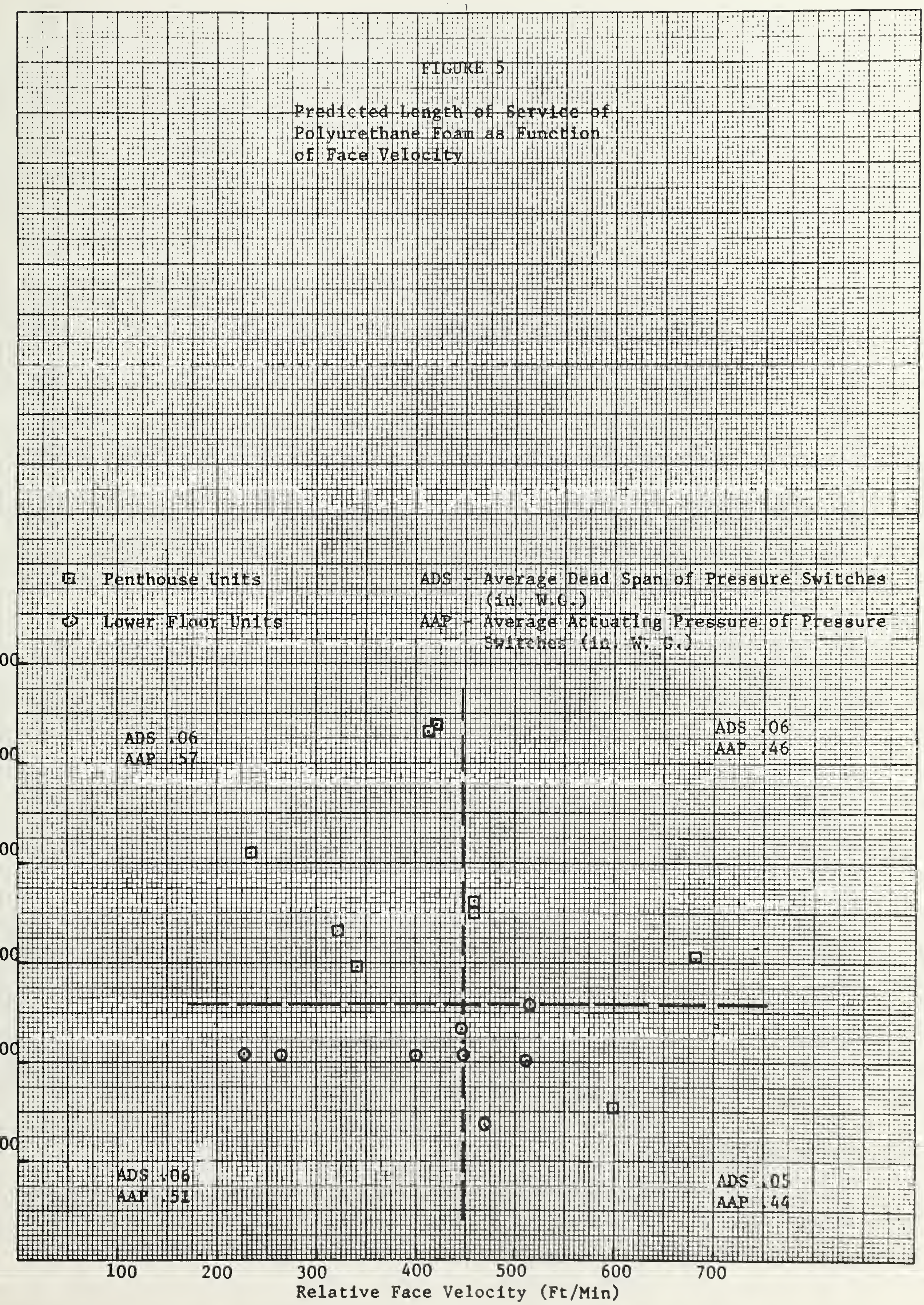
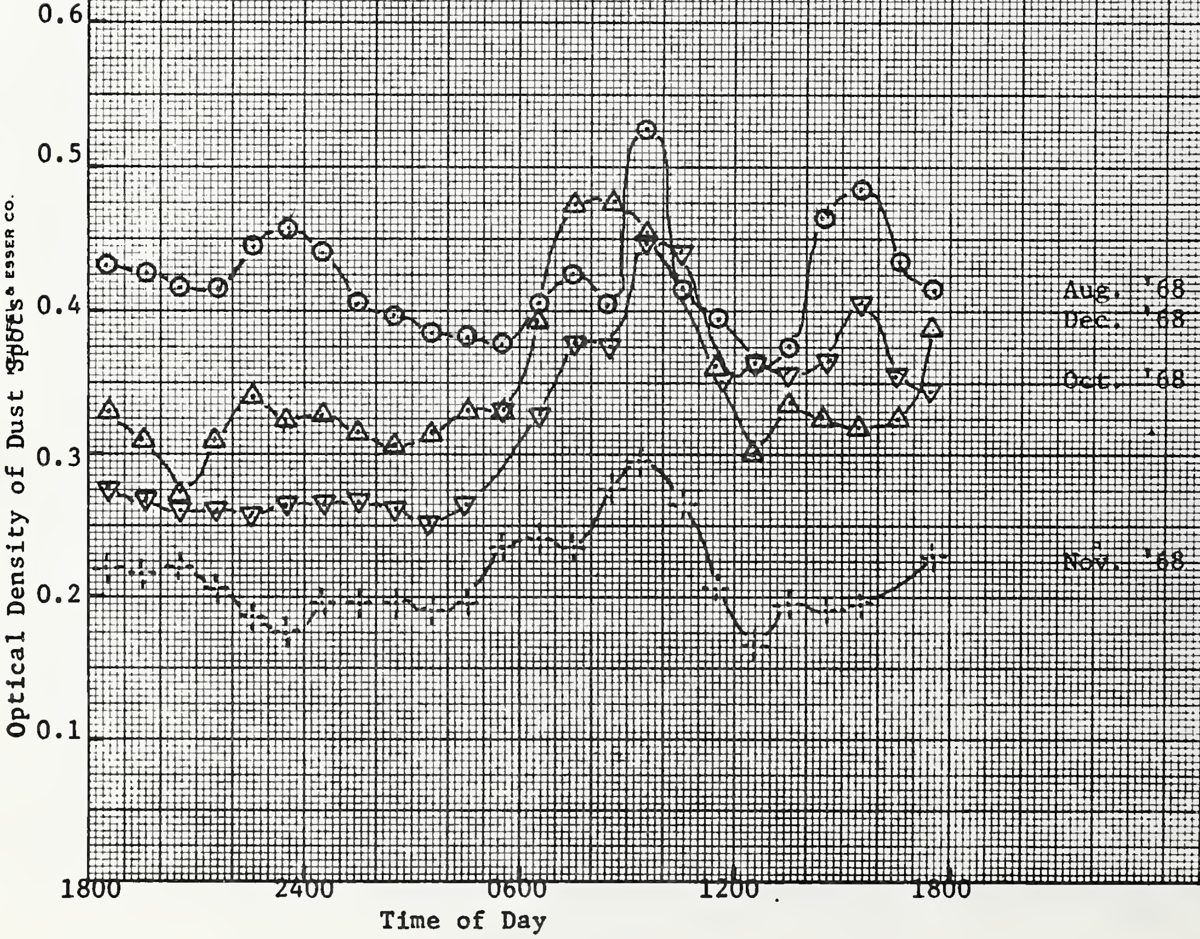


FIGURE 5

Predicted Length of Service of Polyurethane Foam as Function of Face Velocity

FIGURE 6

Average Diurnal Changes in Airborne Dust Level in Test Units



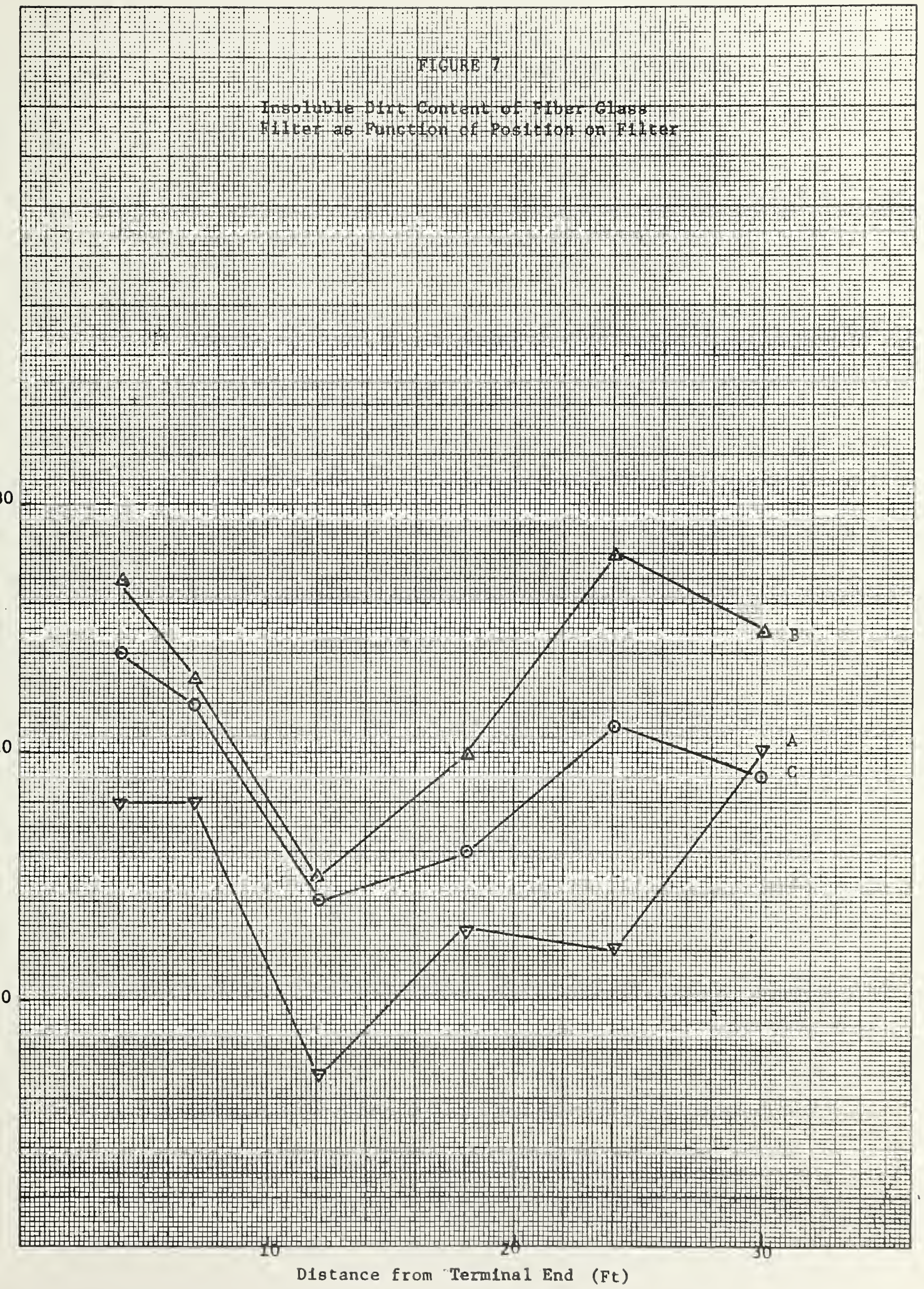


FIGURE 7
Insoluble Dirt Content of Fiber Glass Filter as Function of Position on Filter
30
0
0
B
A
C
10
20
30
Distance from Terminal End (Ft)

APPENDIX A

Evaluation of Farr Metal Viscous Impingement Filters with Automatic Washing and Oiling System

1. Introduction

One of the air handling units at the Philadelphia Main Post Office contains an installation of Farr metal viscous impingement filters with auxiliary equipment for automatically washing and reoiling the filters. This appendix undertakes to evaluate this system from the standpoint of dust arrestance, air flow resistance, and cleaning characteristics, and to compare the performance, where possible, with that of polyurethane foam and glass fiber filters in use in the other air handling units.

2. Description of filter system

The Farr automatic water wash system at the Philadelphia Main Post Office consists of a number of banks of 18 x 18 inch metal viscous impingement filters covering an area of about 85 ft^2. The filters are mounted at an angle of about 35 to 45 ° with the vertical to increase the effective filter area and also to help control the penetration of water and adhesive during the cleaning and oiling cycle. An auxiliary plumbing system with spray jets is provided to direct water against the filters and wash them at approximately 72-hour intervals, as directed by a timer. After washing and drying, adhesive is sprayed on the filters. In principle the Farr unit is intended to be a permanent self-cleaning type of air filter system.

3. Results

A. Dust Arrestance

Dust arrestance measurements were made by means of paper tape samplers upstream and downstream from the filters. The results are shown in table A-1. The average arrestance was based on 17 hourly spots taken from about 5 o'clock in the afternoon until 10 o'clock the following morning. Data obtained during the same week with polyurethane foam and glass fiber media are also shown in the table.

Table A-1

Average dust spot arrestances of Farr viscous impingement, polyurethane foam, and fiber glass filters

	Farr water wash (in unit 4D)	No. Spots	Glass (in unit 2D)	No. Spots	Polyurethane (in unit 2C)	No. Spots
Nov. 20-21	-	-	16 ± 12	23	14 ± 8	21
Nov. 21-22	19 ± 8	17	-	-	21 ± 7	17

The average arrestance of 19 percent for the Farr filters may be slightly higher than the values for glass or polyurethane, but in view of the rather large standard deviation in the arrestance determinations, it would be difficult to establish the Farr filter as definitely superior or inferior to the other filters on the basis of these data.

B. Resistance to air flow and cleanability

When the Farr installation was inspected in December 1968, the pressure drop across the filters was 0.95 in. W.G. This may be compared with 0.4 to 0.6 in. W.G., the upper pressure switch setting in most of the units containing polyurethane foam and fiber glass. The water jets on the Farr unit were directed against the filters for one full minute. After drying overnight the pressure drop was 0.85 in. W.G., indicating that it was not easy to get dirt out of the filters by washing in place.

Post office maintenance personnel report that the automatic washing feature is not satisfactory, and that it is necessary to remove the filters from time to time to wash them. If this system were installed in all of the air handling units at the Philadelphia Main Post Office, this would involve the periodic washing of several hundred individual filters.

4. Conclusions

The Farr water wash system may be satisfactory as a prefilter or roughing filter from the standpoint of dust arrestance. However the greatest shortcoming of the unit is the inadequacy of the automatic cleaning system.

It should also be pointed out that the Farr Company no longer manufactures this type of unit with the automatic washing feature.

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