FILTRATION OF MICROORGANISMS FROM AIR BY GLASS FIBER PAPER FILTERS

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A survey of laboratory acquired infections in the United States reported in 1951 by Sulkin and Pike (1) tabulates a total of 1,334 infections acquired in the laboratory. Filtration of exhaust air from ventilated bacteriological work hoods and from rooms or buildings used in the study of highly infectious diseases will therefore assist in the reduction of laboratory acquired infections.

At the last Air Cleaning Seminar a paper was presented on the "Removal of Bacteria and Bacteriophage from the Air by Glass Fiber Filters." Mention was made at that time that preliminary tests indicated a high filtration efficiency of microorganisms through glass fiber paper filters. Since then, a number of tests have been conducted on this type of filter media. During the past year filter manufacturers have devoted considerable time and effort to the development of ultra microfine glass fiber paper filters for removal of biological and radiological contamination from air supply systems.

The glass fiber filter originally developed jointly by the Department of the Navy and the National Bureau of Standards is now being produced commercially. This filter is as thin as coarse paper (10 mils). The fibers are known commercially as type E Glass Micro Fibers, have a melting point of 1450 F, and an average diameter of 0.5 to 0.75 microns.

A second new type of filter paper is being developed by a research and engineering organization. This second type is composed of a mixture of glass fibers and asbestos fibers. Figures 1, 2, and 3 show the fibers as they appear in the PF 105 spun glass fiber pads and the two newer filter papers. It is evident that the Type E filter material (figure 3) has the most uniform fibers. It was reported at the 1952 meeting that two layers of PF 105 spun glass exhibited an efficiency of 99 per cent in removing Serratia indica from an air stream. Since that time, glass paper filters have been evaluated.

Serratia indica a harmless elongated bacterial organism, about one micron in length and one half micron in thickness was used to evaluate the efficiency of the filter papers. The test equipment is illustrated in figure 4. The organisms were atomized by a Chicago type nebulizer into a cloud chamber where the cloud of bacteria was mixed with air, then passed into the pre-filter sampling chamber, through the filter at face velocities of 10 and 20 feet per minute into a post-filter sampling chamber, and finally exhausted by means of a blower to the outside air. Biological material from this nebulizer is not always unicellular, because agglomeration of organisms may occur during or after release of the aerosol.

The air was sampled in front of the filter by liquid impingers constructed with a critical orifice which permitted air to be drawn through the collecting medium at approximately 0.5 cubic feet per minute. The collecting medium in the impingers consisted of 20 ml nutrient broth and 6 to 8 drops of olive oil. One-tenth ml of the sample was streaked

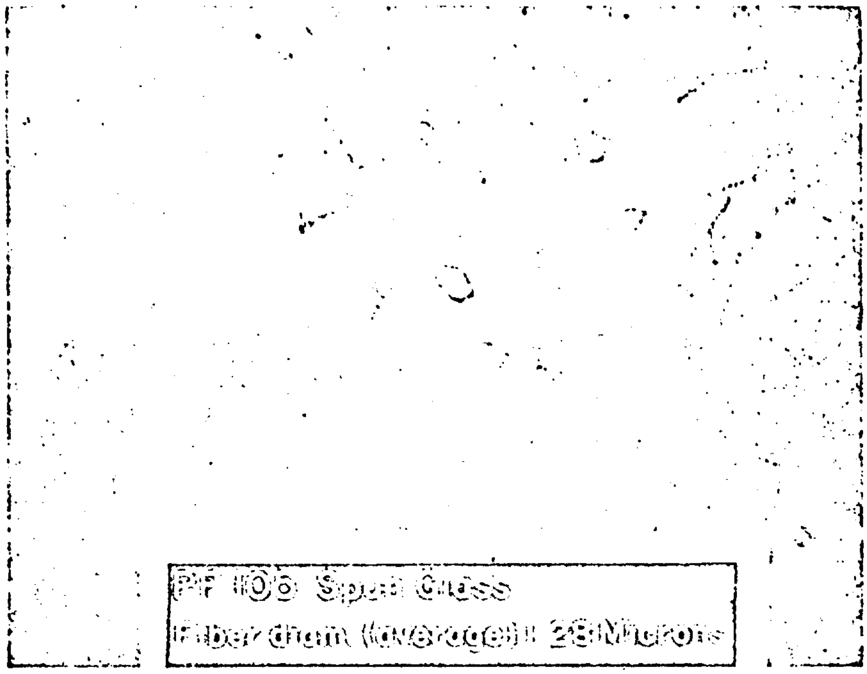


FIGURE 1. PF 105 Spun Glass Filter Media

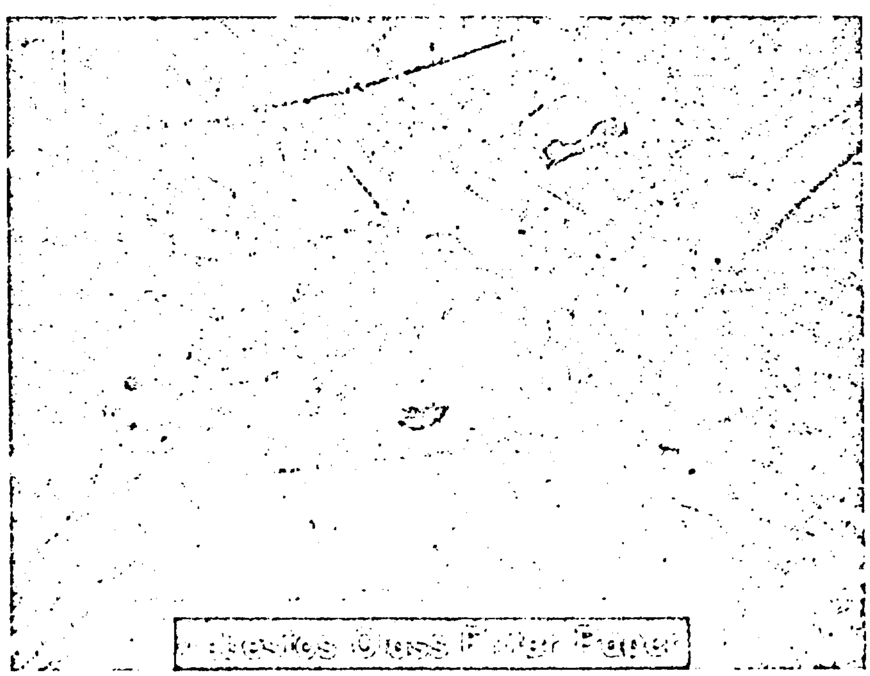


FIGURE 2. Asbestos Glass Filter Paper

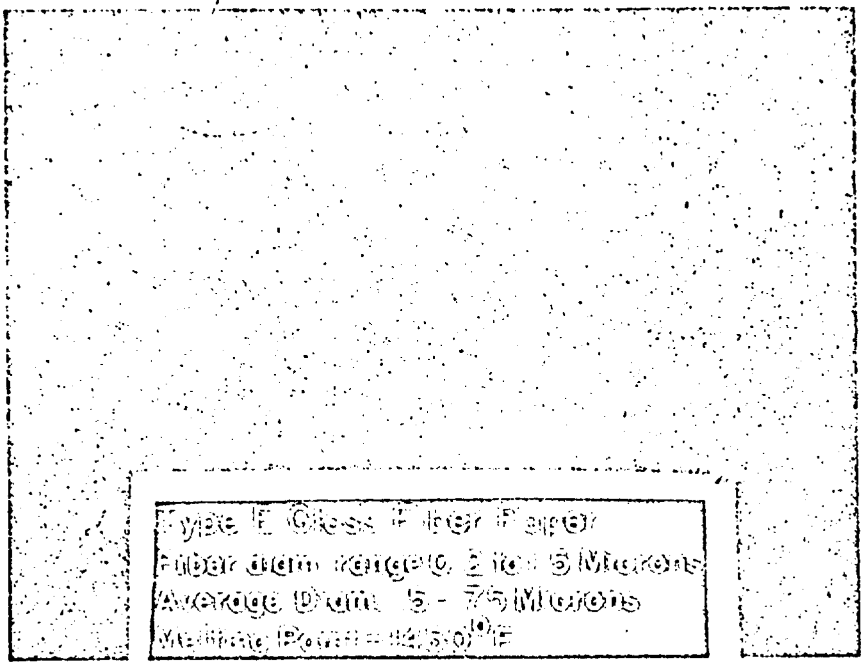
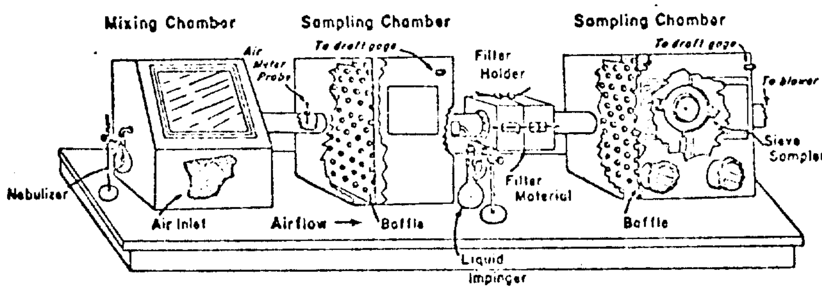


FIGURE 3. Glass Filter Paper



Air Filtration Test Unit

FIGURE 4. Air Filtration Test Unit

on a corn steep agar plate. In addition, one ml samples from the liquid impingers were serially diluted and one-tenth ml samples of the dilutions were streaked on plates for incubation and counting. Sieve samplers containing corn steep agar petri plates were used to sample air after it had passed through the filter.

The efficiency of the filter paper was determined by sampling the cloud concentration before and after the filter. The results of the test are shown in figure 5. At an air flow of 20 linear feet per minute penetration of S indica through the type E glass filter paper was two organisms from each 100 million test organisms recovered in front of the filter. At an air flow of 10 linear feet per minute the penetration was one organism. With the asbestos-glass paper, at an air flow of 20 linear feet per minute, the penetration was 28 organisms per 100 million test organisms. When the air flow through the asbestos glass paper was reduced to 10 linear feet per minute the penetration increased to 140 organisms. The increase in penetration from 28 to 140 probably results from the lesser impingement of the organisms on the fibers at the lower velocities.

Since steam is frequently used in safety cabinets for biological decontamination purposes, tests were conducted to determine whether the passage of steam through the type E glass filter material would have an effect on the filtration efficiency. Free flowing steam was passed through a 100 CFM type E glass pleated filter for a total of three hours. The results of the tests indicated that there was no apparent change in filtration efficiency.

EFFICIENCY OF GLASS AND GLASS-ASBESTOS FILTERS IN REMOVAL OF S INDICA FROM AN AIR STREAM

FILTER MATERIAL EVALUATED	AIRFLOW (linear feet per minute)	RESISTANCE (inches of water)	NUMBER OF FILTERS* EVALUATED	PENETRATION (per 100 million org. recovered before filter)
GLASS PAPER FILTER TYPE E	20	3.2	7	2
	10	1.5	5	1
ASBESTOS-GLASS PAPER	20	3.1	5	28
	10	1.5	5	140

*Each filter was tested a minimum of ten times.

FIGURE 5. Efficiency of Glass and Glass Asbestos Filters in Removal of S indica From an Air Stream

CONCLUSIONS

The data obtained on the filtering efficiency of the filter pads and papers are most promising, and indicate possibilities for wide practical application. Results of our earlier work showed that two ½ inch pads of 1.28 micron size spun glass at a linear air flow of 20 fpm removed an average of 99 per cent of the bacteria and virus organisms. It was felt that this type of air filtration system would be satisfactory for general building exhaust supplies such as in hospitals and in industrial concerns. However, in specialized circumstances such as in the case of some research institutions where organisms may be handled in large numbers or in apparatus in which significantly infectious bacterial aerosols are accidentally or deliberately created, a greater arrestance is necessary.

There is now available a highly efficient mineral filter paper that can be easily used at high temperature; is fire resistant, does not disintegrate when wet, and can be biologically decontaminated by heat.

A non-combustible filter frame for the all-glass fiber filter is being developed commercially (figure 6). The filter made of asbestos fibers and glass fibers is also approaching commercial availability. Industrial installations, hospitals and research laboratories which require removal of biological, radiological or other particulates from an air stream, now have access to a highly effective, fire resistant and chemical (except hydrogen fluoride and alkalies) filter. Frequently, such a filtration system may be used in lieu of a costly incinerator.

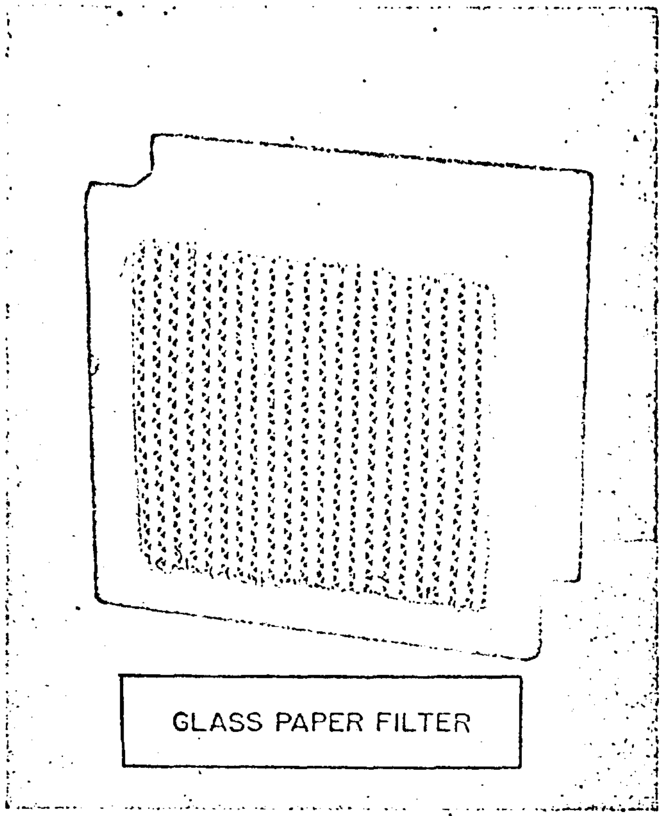


FIGURE 6. GLASS PAPER FILTER

REFERENCE

(1) Survey of Laboratory Acquired Infections, Sulkin, E.S. and Pike, R.M. American Jl. of Pub. Health, 1951, Vol. 41, pp 769-781.