NATIONAL BUREAU OF STANDARDS REPORT

6673

AIR DELIVERY AND ARRESTANCE TESTS OF A
"PURITRON" AIR CLEANER, MODEL F-20

Manufactured by
Michael Electric Company
New Haven, Connecticut

by

Carl W. Coblentz
and
Paul R. Achenbach

Report to

Bureau of Medicine
Food and Drug Administration
Department of Health, Education, and Welfare
Washington, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Air Conditioning, Heating, and Refrigeration Section
Building Technology Division

to

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1. INTRODUCTION

At the request of the Bureau of Medicine, Food and Drug Administration of the Department of Health, Education and Welfare, tests were made of the air cleaning characteristics of a Puritron Air Cleaner manufactured by the Michael Electric Co. Inc. of New Haven, Connecticut. The scope of the investigation was limited to measurements of the arrestance of atmospheric dust, the air delivery of the unit with the filter in a clean condition and also with it partially loaded with dust and lint, and qualitative observations of the arrestance of ragweed pollens and tobacco smoke.

2. DESCRIPTION OF TEST SPECIMEN

The test specimen was a Puritron model F-20, manufactured by Michael Electric Company, Inc., New Haven, Connecticut. It was supplied to the National Bureau of Standards by the Food and Drug Administration, Bureau of Medicine and was identified as their specimen 47-603P, 11-26-58, AJB. The overall dimensions of the unit were 9 1/2" long, 7" high, and 7 1/8" deep. An outlet grille 2 5/16" wide and 2 5/8" high protruded 3/8" from the front side. Air entered the casing through five 3" long louvers on the top of the unit. The housing was made of sheet steel with a gray enamel coating. Figure 1 is a three-quarter view of the specimen showing the inlet louvers and outlet grille.

The incoming air passed around three germicidal lamps of 4 watts each, made by General Electric Co., and then through a "Dust-Stop" fiber glass air filter made by the Owens-Corning Corp. The outside dimensions of the filter were 6" x 4" x 7/8" thick with an effective face area of approximately 2 1/4" x 4 1/4". The downstream side of the filter was placed against the 2 1/2" I.D. intake opening of the fan housing. The rotating element of the fan consisted of a flat steel sheet about 3" x 1" which was attached to the shaft of an electric motor, along the shorter center line of the sheet to form a paddle-wheel type of element. The unit was equipped with an electric cord for connection to an ordinary convenience outlet.

Figure 1

3. DESCRIPTION OF TESTS

3.1 Determination of the Air Flow Rate

Measurement of the air velocity at the plane of the outlet grille, using a thermocouple anemometer, produced readings over a range from 700 to below 100 ft/min. Five directional vanes turned slightly upward and a 1/4" wide vertical brace in the center of the outlet apparently produced secondary vortices at the grille. Due to this non-uniformity of the velocity at the face of the grille, it was necessary to determine the velocity at a large number of stations to obtain an average.

A cardboard collar 2 5/8" x 2 3/8" was placed snugly around the grille. It projected 7/8" at the top and 13/16" at the bottom in order to provide a vertical outlet plane. The collar was then marked at 1/4-inch intervals along the top and one side to identify a measurement pattern consisting of 90 equal areas.

The velocity pressure of the air stream was determined with a 1/16" O.D. nickel impact tube and a micromanometer that could be read to the nearest 0.001 in. W.G. The nozzle end of the impact tube was 10 in. long, thus avoiding a disturbance of the air flow. It was placed successively at the center of the marked square areas in the outlet plane of the cardboard collar. There was a strip of 1/16" width left around the periphery of the collar not covered by the 90 squares. Disregarding the air flow through the area of this strip, the total air flow rate of the unit, Q (cfm), was then the sum of the air flow rates determined for each individual square, q (cfm)

$$Q = \sum q \text{ (cfm)}$$

where: $q = a \times v$ (cfm)

$a = (1/4 \times 1/12)^2$ (sq ft)

$v = 4008 \times \sqrt{h}$ (ft/min) for air at standard conditions

h = the velocity head determined at the center of each 1/4" square (in. W.G.)

Therefore:

$$Q = \sum \left[(1/4 \times 1/12)^2 \times 4008 \times \sqrt{h}\right]$$

or

$$Q = (1/4 \times 1/12)^2 \times 4008 \times \sum\sqrt{h}$$

$$Q = 1.735 \times \sum\sqrt{h} \text{ cfm}$$

When making these velocity pressure measurements with the clean filter in place, positive velocity pressures could be observed in 62 squares. The lower 1/2" of the outlet showed either zero or a negative velocity pressure which indicated that air was aspirated into a portion of the outlet. A suction pressure of 0.004 in. W.G. was observed in several squares corresponding to an inward flow velocity of approximately 231 ft/min. In computing the total air delivery, both the inward air flow and the air flow in the 1/16" wide strip at the periphery were neglected. Either of the two amounted to less than 5 percent of the total air flow rate, and the inward flow in the lower part of the collar was estimated to be higher than the outward flow along the upper edge. The velocity in the peripheral strip at the sides of the collar was near zero at all places. The air flow rate, thus determined, for the unit with a clean filter was 12.3 cfm. This value is believed correct to ±1 cfm.

The Puritron unit was then installed in the test duct of the NBS air filter apparatus and Cottrell precipitate and cotton lint, in a ratio of 96 to 4 by weight, was introduced while the Puritron was operated. After the weight of the filter had increased by 2.7 grams, another series of velocity measurements was made using the same stations of observation. A total air flow rate of 7.84 cfm was calculated from positive pressure heads observed in 64 individual squares. No aspirating air flow was observed in the lower section of the outlet during this test. Based on the velocity patterns in a vertical plane observed during this test and the preceding test with a clean filter, it was estimated that the average air flow rate in the remaining 26 squares did not exceed 100 ft/min. On this basis, the total air flow rate did not exceed 8.97 cfm for this test. An air velocity of 100 ft/min corresponds to a velocity head of 0.00067 in. W.G., which is below the sensitivity of the micromanometer used. On the basis of these observations, the total air flow rate with a load of 2.7 grams of dust was between 7.8 cfm and 9.0 cfm. This dust load corresponds to a value of about 40 grams/sq ft of face area and is less than that which can be accumulated on similar filters for air conditioning purposes at full load by a factor of three or four.

3.2 Determination of Arrestance

Arrestance determinations were made by the NBS "Dust Spot Method" using the particulate matter in the laboratory air as the aerosol. The test method is described in the paper, "A Test Method for Air Filters," by R. S. Dill (ASHVE Transactions, Vol. 44, p. 339, 1938).

The Puritron was placed on a table and operated from the 115-volt electric service. The upstream and downstream samples of air were drawn from the vicinity of the air inlet louvers and about 2 in. horizontally from the center of the upper edge of the outlet grille, respectively. The sampling air was passed through known areas of Whatman No. 41 filter paper at very nearly equal flow rates as determined with two calibrated orifice flow meters. The change of opacity of the exposed areas of the sampling papers was determined with a sensitive photometer which measured the light transmission of the same area on each paper before and after the test. The two sampling papers used for each test were selected to have the same light transmission readings when clean. The arrestance, A, was then calculated by the formula:

$$A = \left(1 - \frac{F_D}{F_U} \times \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U}\right) \times 100, \text{ percent}$$

where: F_D = flow rate of downstream sampling air

F_U = flow rate of upstream sampling air

S_D = collection area on downstream filter paper

S_U = collection area on upstream filter paper

ΔD = change in opacity of downstream sample

ΔU = change in opacity of upstream sample

The tests were conducted with a clean filter in a calorimeter room where the relative humidity could be raised above that normally prevailing in a heated room during the heating season. Six arrestance determinations were made at the normal relative humidity and four measurements of the arrestance were made at higher relative humidity.

In order to determine the effect of the ultraviolet lamps on the arrestance of the unit, half of these tests were made with the lamps removed and the other half with the lamps operating. Table 1 shows the values of the arrestance determined under these conditions.

Table 1

Arrestance of Particulate Matter in the Laboratory Air

Relative Humidity	21-22%		54-60%	
Ultraviolet Lamps	in	out	in	out
Arrestance, %				
Test Series 1	19.7	21.6	31.4	41.2
Test Series 2	19.9	30.7	40.2	41.6
Test Series 3	22.7	16.4		
Average Arrestance, %	20.8	22.9	35.8	41.4

Although there was some variation in the arrestance values determined for repetitive tests under the same conditions, it appears that the arrestance was a little higher on the average when the germicidal lamps were removed than when they were in and operating, at both the higher and lower level of relative humidity. The arrestance at the higher humidity level was definitely larger than at the low humidity level.

3.3 Removal of Cigarette Smoke and Ragweed Pollen

After making the arrestance tests, but prior to loading the filter with the 2.7 grams of dust and lint, cigarette smoke was blown from the mouth of a staff member through a paper straw into the vicinity of the intake louvers of the operating specimen. Figure 1 shows the procedure used and the qualitative result. The photograph clearly shows a significant amount of the smoke emerging from the outlet grille after having penetrated the test specimen with the filter in place and the ultraviolet lamps operating.

Ragweed pollen was also introduced into the test specimen and a microscopic slide was mounted approximately 1 in. from the outlet grille. This slide was prepared with an adhesive and the deposit by the effluent was exmained with a microscope. It showed after each of several tests that ragweed pollen had passed through the Puritron device and was deposited on the microscopic slide. No quantitative data on the arrestance of ragweed pollen were obtained.

4. DISCUSSION AND CONCLUSIONS

a) The air delivery determined with a clean filter was 12.3 cfm ±1 cfm and, with a filter loaded with 2.7 grams of dust, was 8.4 cfm ±0.6 cfm.

b) The arrestance of particulate matter in the laboratory air was lower when the germicidal lamps were installed and operating, than when they were removed. This difference may have been caused by a somewhat higher air flow rate that probably resulted from elimination of the flow resistance of the three lamps.

The arrestance increased by about 80 percent when the relative humidity level was increased from the range of 21-22% to the range of 54-60%.

c) Cigarette smoke blown at the inlet of the unit could be seen leaving the outlet grille as shown in Figure 1. The penetration of ragweed pollen fed into the unit was indicated by the deposit of such pollen on a microscopic slide that had been mounted close to the outlet grille.

d) An advertising folder for Puritron states that the Model F-20 is suitable for a room with dimensions of 15' x 15'. Such a room, with an 8' ceiling height, would have a volume of 1800 cubic feet. It is not unusual for residential living spaces to have an outdoor air leakage of 1 airchange per hour, which, for the example cited, would be equivalent to 30 cfm of outdoor air.

A calculation can be made to determine how much the Puritron could reduce the particulate matter in a room of this size with an outdoor air leakage of 30 cfm and no contribution to contamination from inside the room, as follows:

If C_o is the volumetric concentration of particulate matter in the outdoor air, the total particulates entering the room per minute would be 30 C_o.

If C_i is the steady state volumetric concentration of particulates in the room after the Puritron has been operating for a sufficiently long time, the total particulates leaving the room per minute would be:

$30\ C_i + 12 \times .36 \times C_i$ assuming that the Puritron was circulating 12 cfm and had an arrestance of 36%.

Under steady state conditions, the total rate of entry and removal of particulates would be equal or

$$30\ C_i + 12 \times .36 \times C_i = 30\ C_o$$

and $C_i = 0.87\ C_o$

If particulate matter was contributed to the air from activities in the room, the interior concentration would be a higher percentage of the outdoor concentration, and could exceed the outdoor concentration under certain conditions.

U.S. DEPARTMENT OF COMMERCE
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Optics and Metrology. Photometry and Colorimetry. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research.

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