NATIONAL BUREAU OF STANDARDS REPORT

10 816

PERFORMANCE OF TWO SMALL ROOM-TYPE ELECTROSTATIC AIR CLEANERS WITH SELF-CONTAINED FANS

Report to
Food and Drug Administration
Washington, D. C. 20204

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] Part of the Center for Radiation Research.
[3] Located at Boulder, Colorado 80302.

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Abstract

Two similar electrostatic air cleaners, each with its self-contained fan, were tested for efficiency using the atmospheric dust spot test and for air moving capacity. The dust count in a closed room was also measured with a light scattering particle counter before, during, and after operation of each device. The atmospheric dust spot efficiencies ranged from 37 to 43 percent with fans on high speed and 42 to 51 percent on low speed. The net movement of air through the devices were 63 and 68 cfm, respectively on high speed and 56 and 58 cfm on low speed when measured by a null pressure drop method in a test duct. Anemometer measurements indicated higher flow rates at the exhaust but lower values at the intake. Operation of the devices for two hours in a closed 2000 ft^3 room produced a measurable decrease in the dust count.

Key Words: Airborne particulate removal; dust abatement; electrostatic air cleaners

1. Introduction

At the request of the Food and Drug Administration (FDA), two electrostatic air cleaners with small self-contained air circulating fans were tested. These air cleaners were delivered to this laboratory by Mr. Robert J. Kennedy of FDA under designation PS052-441E. The units were labelled A and B in this laboratory to distinguish them from each other and are so marked. Label A corresponds to manufacturer's Serial No. 005666 and B corresponds to Serial No. 005415.

The scope of the tests included measurement of dust spot efficiency using atmospheric dust as the test aerosol, measurement of the air moving capacity of the devices by two methods, and dust counts in a 2000 ft^3 room before, during, and after operation of each of the units.

2. Description of the Air Cleaners

The air cleaning units, which were the test devices in these measurements, were of metal construction. Each unit measured approximately 6 inches high by 12 inches wide by 11 1/2 inches deep. The front air intake measured 10 1/2 by 2 1/4 inches and the outlet at the rear measured 11 1/2 by 2 3/4 inches. Both were covered by grilles. Each unit had two thin horizontal ionizing wires just inside the front grille, and behind these were collector plates. A fan was mounted in the rear of each unit with its axis of rotation oriented vertically. Part of the air came through holes in the bottom of the device and was directed out the back, and part of the air was drawn through the electrostatic air cleaner. The devices had two fan speeds, high and low.

3. Dust Spot Efficiency

The test unit was mounted in a test duct as shown in Figure 1. A corrugated cardboard diaphragm was sealed to the front face of the device and sealed to the mounting frame in such a way as to allow free passage of air through the device without allowing bypass around it. The device was turned on and operated with its own fan. The duct fan (shown in Figure 1) was off.

Efficiency measurements were made using the NBS dust spot method for air filters (ASHVE Transactions, Vol. 44, p. 379 (1938)). Samples of atmospheric air were drawn 1 1/2 feet upstream and 8 ft downstream from the operating test device and passed at equal rates through Whatman No. 41 filter papers. Sampling through the downstream paper was continuous, while sampling through the upstream paper was controlled by a timer, the "on" time being selected by trial and error to give upstream and downstream dust spots of approximately equal optical density. The discoloration of the spots was determined by measuring the same areas of the papers before and after the test. The percent dust removal efficiency E was calculated by the formula

$$E = (1 - t_u \frac{\Delta D}{\Delta U}) \times 100$$

where t_u is the fraction of time sampled upstream, and ΔU and ΔD are the observed change in the amount of light passing through the upstream and downstream papers.

The results of the test are summarized in Table 1. The values are well below the 90 percent efficiency required by Federal Specification FF320 for electrostatic air cleaners. However, the air cleaners are of intermediate efficiency. That is, they are superior in efficiency to typical roll filters or viscous impingement filters of the type commonly used in air conditioning and ventilating systems.

4. Air Moving Capacity

Measurements of air movement were made by holding the probe of a hot wire anemometer at several points across the air inlet of each test unit about 1/8 to 1/4 inches from the grille. In this way a "scan" was obtained from which average air flow rate was calculated. The process was repeated at the rear of each device. The results of these averaged measurements, expressed as a volume flow rate, are given in Table 2.

It should be pointed out that the method of measurement suffers from the limitation that it is difficult to obtain a representative average scan across the face of the device, particularly when the air flow pattern is unsymmetrical. Also, the reading obtained is quite sensitive to the distance between the probe and the entrance or exit grille, and finally, the anemometer reads in feet per minute. To convert this reading to cubic feet per minute (cfm) it is necessary to multiply by the cross sectional area of the airstream, and there is some uncertainty as to the exact area. However, the results in Table 2 show that the flow rate from the rear of each device is greater than the flow rate into the front. This is due to the fact that air is drawn in both at the bottom and front of the device and discharged at the back.

A second method for measuring the air moving capacity was used which measured net movement through the front grille of the test device. The unit was mounted in the same way as in the dust spot test and turned on. The pressure drop across a 2 3/4 inch orifice plate at the entrance to the test duct (Δp_1 in Figure 1) and the pressure difference across the test device (Δp_2 in Figure 1) were measured. The flow rate through the orifice and through the test device was based on Δp_1. However, this pressure drop imposes an extra load on the fan in the test device. Therefore, this initial flow rate does not represent flow through the unit in normal operation. To compensate for this the duct fan was operated downstream from the test device, and Δp_1 and Δp_2 were again measured at a number of duct fan speeds. In this way curves of flow rate versus pressure difference across the device were obtained, as shown in Figure 2. In this figure, pressure rise across the test device is arbitrarily represented as a negative quantity and pressure drop as a positive quantity. The flow rate at which there is no pressure difference across the test device is the air moving capacity. Flow rates measured in this way are summarized in Table 3. The values are intermediate between anemometer values measured at the front and back of the test device given in Table 2, but they are closer to the estimated flow rate into the intake than the exit flow rates.

5. Dust Count in a Room

Each test device was placed in a closed 2000 ft^3 room having a natural air exchange rate of less than 0.1 change per hour. This is a much lower rate than is customary in occupied spaces. A light scattering particle counter was placed in the room with its sampling inlet about 3 feet from the air intake of the test device. Counts were made of particles larger than 0.3 μm* for about 1 1/2 hours before each air cleaner was turned on for 2 hours while it was in operation, and for 2 hours after it was turned off. The room was entered only to set up the measurement and to turn the device on and off. The results are shown graphically in Figure 3. The curves show a superposition of the natural decrease in count of particles in a closed space without the air cleaner operating, plus the particle removing effect of the air cleaner. The test is not sufficiently standardized to express the results as fraction particles removed from the room. However, the curves show an increase in the rate of particle removal when the devices are turned on and a rise in count after they were turned off. The initial count was higher in the test where unit A was operated with its fan at high speed (upper left part of Figure 3) than in the other tests, because there was smoking in the room prior to the test.

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* μm is the symbol for the micrometer or 10^{-6} meters. The unit and symbol are in accord with the International (S.I.) system of units. A micrometer is equivalent to a micron - μ.

Table 1

Atmospheric Dust Spot Efficiency of

Electrostatic Air Cleaners - Percent

Fan Speed	High	Low
Unit A	40	42
	37	45
Unit B	43	51
	37	43
		43

Table 2

Air Moving Capacity of Electrostatic Air Cleaners

Measured by Anemometer Scan - cfm

Measured at Rear

	High	Low
Unit A	101	79
Unit B	108	97

Measured at Front

	High	Low
Unit A	58	49
Unit B	55	42

Table 3

Air Moving Capacity of Electrostatic Air Cleaners Measured in Test Duct - cfm

	High	Low
Unit A	68	58
Unit B	63	56

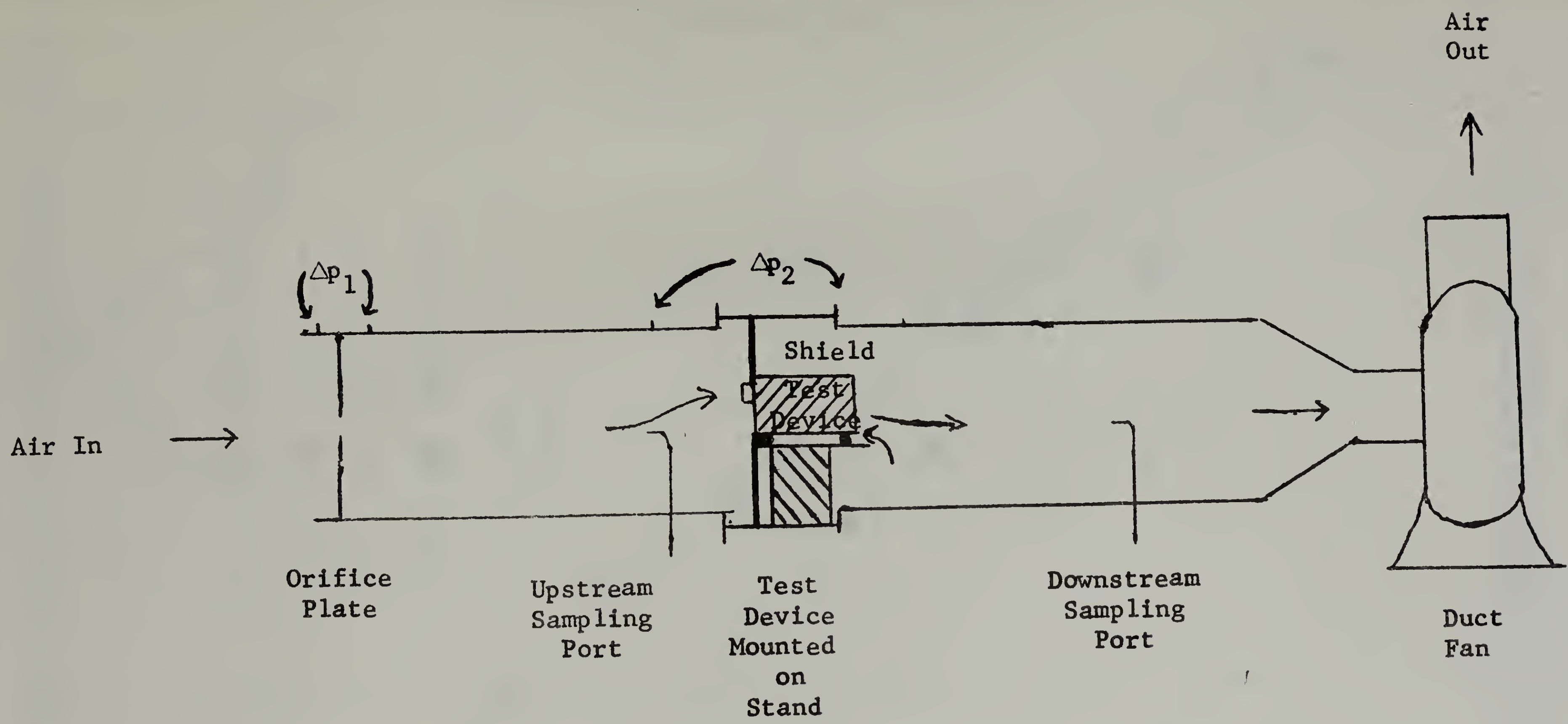
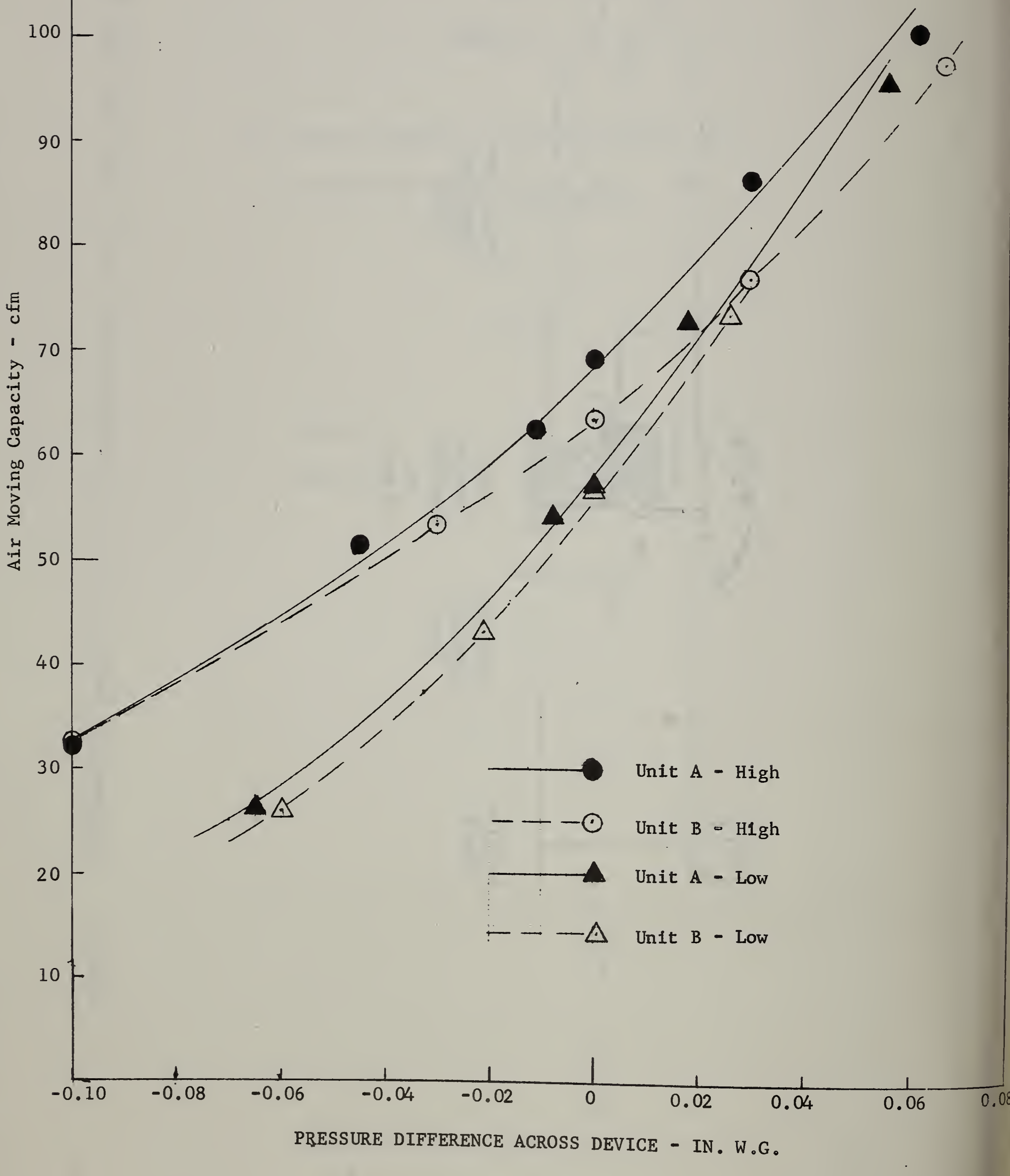


Figure 1 Diagrammatic Representation of An Electrostatic in the Test Duct (Not Drawn to Scale)

Figure 2 Net Air Moving Capacity of Portable Electrostatic Air Cleaner as a Function of Pressure Difference Between Outlet and Inlet



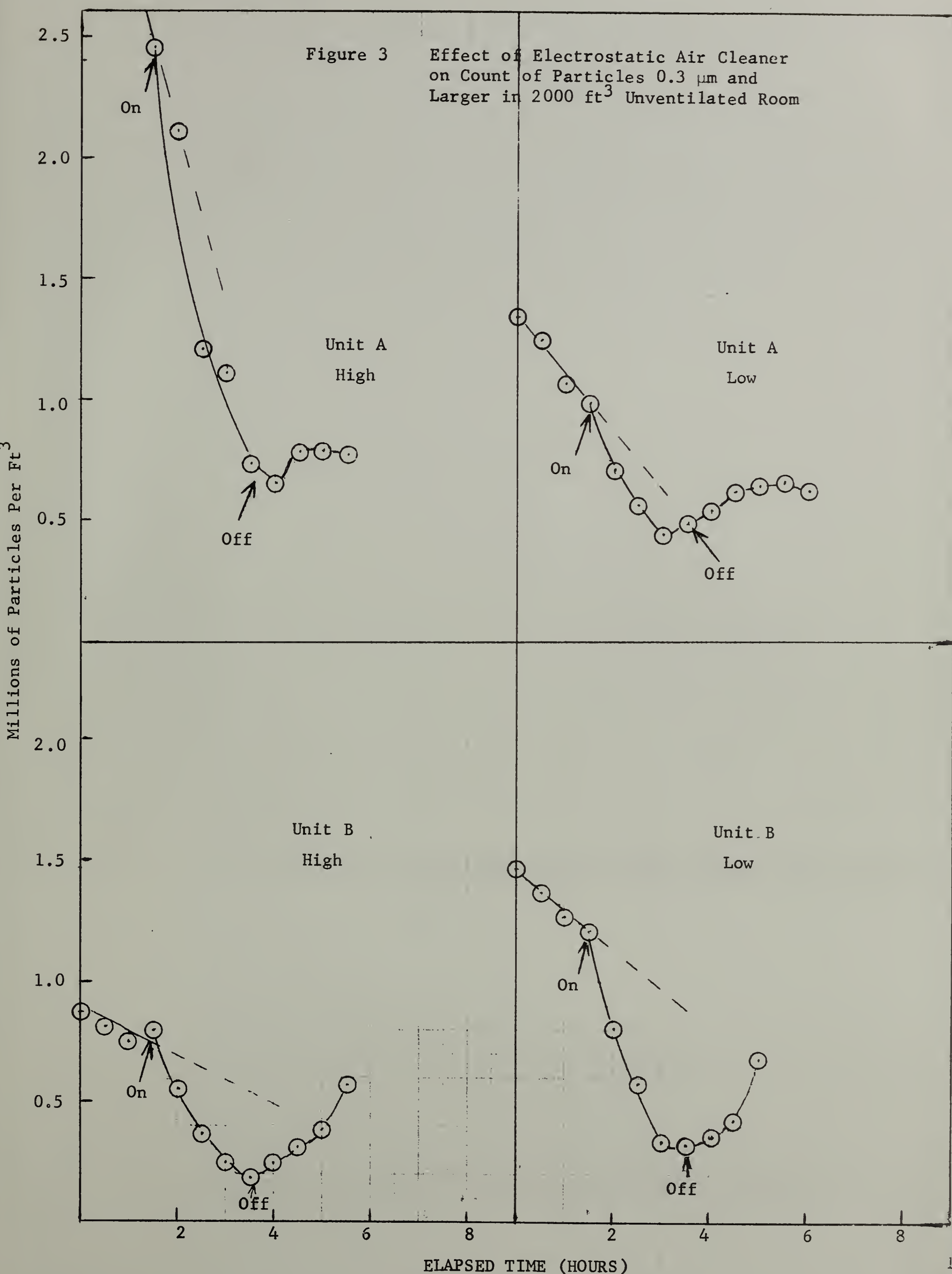


Figure 3
Effect of Electrostatic Air Cleaner on Count of Particles 0.3 μm and Larger in 2000 ft³ Unventilated Room
Millions of Particles Per Ft³
2.5
2.0
1.5
1.0
0.5
Unit A
High
Unit A
Low
Unit B
High
Unit B
Low
On
Off
2
4
6
8
ELAPSED TIME (HOURS)

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