NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE TEST OF A MINNEAPOLIS-HONEYWELL
ELECTRONIC AIR CLEANER, MODEL FC1A2

by

Carl W. Coblentz and Paul R. Achenbach

Report to
General Services Administration
Public Buildings Service
Washington 25, D. C.

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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to

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1. Introduction

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of a Minneapolis-Honeywell electrostatic air filter unit were determined. The scope of this examination included determination of arrestance of atmospheric dust and Cottrell precipitate, pressure drop, dust-holding capacity and the cleanability of the specimen.

2. Description of Test Specimen

The cleaner was manufactured and supplied for test purposes by the Minneapolis-Honeywell Regulator Company of Wabash, Indiana. The collector cell was identified as the manufacturer's type FC1A2 and the power pack as type FC16A1.

The cell was 18 in. long and was enclosed with little clearance in a housing about 22 in. wide, 24 in. high and 30 in. long which also formed a support for the nominal 20 by 20 by 1 in. afterfilter. This afterfilter was the Research Products Corporation type MV #9852. The upstream and downstream faces of the housing were provided with flanges for incorporating the unit into the test apparatus.

The gross face area of the cell was 22 1/8" by 24", or 3.69 sq ft. The plates were spaced 0.270 in. on center. There were 39 energized plates 20 1/2" high and 11 in. long and 38 grounded plates, all of aluminum sheet 1/32" thick, providing a total plate area of approximately 122 sq ft, corresponding to a total surface area of 244 sq ft. The net face area of the cell after deducting the area taken up by the plates was computed to be 3.01 sq ft. At the design air flow rate of 2000 cfm the mean air velocity between the plates would be 665 ft/min.

Socony-Vacuum cold water adhesive furnished by Minneapolis-Honeywell Regulator Co. was sprayed on the collector plates from upstream and downstream and was also sprayed

on the afterfilter in preparation for the test.

The power pack was 23 1/4" high, 15" deep, and 14" wide and was quoted by the manufacturer's representative to be able to energize six cells of the size tested. It was connected to the laboratory power supply and the energizing voltage was adjusted by the manufacturer's representative prior to starting the tests. The power pack was equipped with an overload breaker in the primary circuit which tripped repeatedly when the test specimen had been loaded with dust to about half its capacity. The original breaker with a rating of 0.8 amperes was then replaced by the manufacturer with another one of the same type but with a rating of 5.0 amperes.

3. Test Method and Procedure

Arrestance determinations were made by the NBS "Dust-Spot Method" using the following aerosols: (a) outdoor air drawn through the laboratory without addition of other dust or contaminant and (b) Cottrell precipitate. The test method is described in the paper, "A Test Method for Air Filters", by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938).

For these tests, the unit was installed in the test duct, and carefully sealed to prevent inleakage of air. The desired rate of air flow through the air cleaner was established and samples of air were drawn from the center points of the test duct one foot upstream and eight feet downstream of the air cleaner assembly at equal rates and passed through known areas of Whatman No. 41 filter paper. For the atmospheric air tests, the samples were drawn at equal rates for one to two hour periods through filter paper areas of different sizes to obtain a similar increase of opacity on the upstream and downstream samplers. The upstream filter paper area selected, had a diameter of 1.850 in. and the downstream diameter was 0.581 in. The resultant arrestance value, then, was computed by the following formula:

$$E = 1 - \left(\frac{0.581}{1.85}\right)^2 \times \frac{\Delta D}{\Delta U}$$

Where ΔD and ΔU are the observed values of the change in opacity of the downstream and upstream samplers, respectively.

Under these conditions, an efficiency of 90.12 percent would have been indicated if the upstream and downstream dust-spots on the filter papers had the same change of opacity, as observed photometrically by the change in the light transmissions of the dust-spot areas before and after the sample was drawn. The filter papers used in the upstream and downstream positions were selected to have the same light transmission readings when clean. The same sampler plates were used for determining the arrestance with Cottrell precipitate as an aerosol. However, since the arrestance value was expected to be considerably higher, two filter papers were used successively in the upstream sampler, each operated for the duration of the introduction of 10 grams of dust into the apparatus, whereas only one sampler was used downstream for the total of 20 grams. This method resulted in more nearly equal discoloration of the individual upstream and downstream filter papers and consequently a more accurate measurement of the discoloration and arrestance. For calculating the arrestance value, the sum of the discolorations of the two upstream sampler papers was introduced as ΔU in the above formula.

The power pack was connected to the 115-volt laboratory power supply through a Variac, the output voltage of which was maintained at about 120 ±2 volts. The measurements of the ionizer and plate voltages were made with a sensitive electrostatic kilovolt meter after adjusting the input to the power pack to 120 ±1/4 volts. The high-voltage current could be observed on a milliameter mounted on the front panel of the power pack.

The following procedure was employed in testing the filter. After the clean and oiled unit had been installed in the test duct, and all discoverable air leaks into its housing had been sealed, its input and output voltages were adjusted to recommended values by a representative of the manufacturer: (input 120 volts; ionizer 14.55KV; and plates 7.05KV). Determinations of the arrestance of the clean unit were made at the rated air flow rate, using outdoor air drawn into the test duct through a nearby open window as the aerosol, and also at air flow rates 20 percent greater, and 20 percent less than the rated air flow rate.

Following these initial determinations, two tests were made at the rated air flow rate, using outdoor air in which was dispersed Cottrell precipitate at a concentration of one gram per thousand cubic feet of air as the aerosol. When these had been obtained, the loading process was begun with a mixture of 4 percent cotton lint and 96 percent Cottrell

precipitate, by weight, separately dispersed into the air stream. The lint used for this purpose was No. 7 cotton linters previously ground in a Wiley mill with a four-millimeter screen. The lint was dispersed into the air stream through an aspirator operating at approximately 35 psi inlet air pressure. At selected intervals, as loading progressed, the arrestance of the unit was determined using 100 percent Cottrell precipitate in the outdoor air. In these tests, and during the loading process, the rate of feed of the dispersant was one gram per thousand cubic feet of air. The pressure drop and the ionizer and plate voltages of the unit were recorded at intervals during the tests. The dirt-loading process was continued until 1340 grams of the lint and Cottrell precipitate mixture had been fed (i.e., 2/3 gram per cfm of unit rating).

The filter cell was removed from the test unit and cleaned by means of a stream of cold water from a high pressure hose nozzle, directed at and into the cell plates from both ends of the unit. The cleanability of the afterfilter was determined separately, by the same means.

4. Test Results

A summary of the test results is presented in table 1 which shows the air flow rates, cumulative dust loads, ionizer and plate voltages and currents, the pressure drops across both cell and afterfilter and the arrestance values determined with atmospheric dust as well as with Cottrell precipitate.

Throughout the tests with atmospheric air, audible electrical discharges occurred at a rate of approximately three times per minute. This rate increased to about 23 discharges when Cottrell precipitate was introduced.

After 976 g of dust had been introduced, the high voltage current reached 1.7 MA and the current overload tripped repeatedly and finally could not be reset. At this time, the 0.8 ampere circuit breaker was replaced with a 5 ampere breaker furnished by the manufacturer. The high voltage current was 3.0 MA immediately after replacing the breaker but went down to 1.9 MA at the conclusion of the test.

Table 1

Performance of the Minneapolis-Honeywell
Electronic Air Cleaner Model FC1A2

Air Flow Rate	Dust Load	Voltage Ionizer	Voltage Plate	Current	Pressure Drop	Arrestance	Aerosol Used*
cfm	grams	kv	kv	ma	in. W.G.	%	
1600	0	14.5	7.05	1.1	0.194	94.6	A
2000	0	14.6	7.05	1.1	0.291	90.5	A
2400	0	14.6	7.2	1.1	0.410	84.3	A
2000	10	14.5	7.0	1.2	0.292	98.5	B
2000	30	14.5	7.0	1.2	0.292	98.5	B
2000	373	14.7	7.0	1.2	0.299	99.3	B
2000	747	14.6	7.0	1.3	0.363	98.9	B
2000	850	14.4	6.9	1.5	0.442	93.4	A
2000	1329	14.3	6.8	2.0	0.692	99.0	B
2000	1340	14.4	6.8	2.0	0.718	91.5	A

* A-Particulate matter in atmospheric air at NBS.
B-Cottrell precipitate in atmospheric air (rate of feed = 1 gram per 1000 cu ft)

5. Summary

A. Performance

At the rated air flow rate of 2000 cfm, i.e. 542 ft/min face velocity, the arrestance of particulate matter in the atmospheric air was 90.5 percent at the beginning of the loading period. When the air flow rate was decreased by 20 percent to 1600 cfm, the arrestance value increased by 4.1% to 94.6 percent; conversely, an increase of the air flow rate through the test specimen by 20% to 2400 cfm reduced the arrestance by 6.2% to 84.3 percent. All subsequent tests were made at the rated air flow rate of 2000 cfm and showed that the arrestance of atmospheric matter increased to 93.4 percent when the unit was about half loaded and then decreased to 91.5 percent at the end of the test.

Four tests made with Cottrell precipitate showed arrestance values between 98.5 percent and 99.3 percent. The highest arrestance value coincided with the peak ionizer voltage of 14.7 KV at a dust load of 373 grams although it was not established that there was a direct relationship between these two variables.

The power pack furnished for this test was said by the manufacturer's representative to be designed to supply up to six cells of the size tested and its performance on one cell during the test, with regard to maintaining an even ionizer and plate voltage with increasing current rates without making any adjustments, is not believed to be indicative of its performance on six cells. A similar conclusion might be justified regarding the original circuit breaker which during the test had to be replaced by one with a higher rating. Since the circuit breaker was a minor auxiliary component that was easily replaced, the test was not terminated when its current rating was reached.

During the process of loading, the pressure drop of the unit increased from 0.291 in. W.G. to 0.718 in. W.G. at the rated air flow rate of 2000 cfm. Thus a dust load of 1340 g (i.e. 2/3 g per 1 cu ft rated air flow rate) produced an increase in the pressure drop of 0.427 in. W.G.

B. Cleanability

The filter was subjected to the cleaning process described under Test Method and Procedure. No difficulty was experienced in cleaning the collector cell and the afterfilter with a cold water stream, using moderate care.

C. General

On completion of the dust loading test, the unit was removed from the test apparatus for a visual examination. All components of the collector cell were coated with dust. The dust layer of the grounded plates was considerably lighter than that of the charged plates. The latter were fairly evenly covered with a layer estimated at 1/32 inch thickness. Only very small lint particles were noticed on the surface of the collector cell but the afterfilter showed a considerable lint deposit on its front side. The back side of the afterfilter was completely clean and did not indicate that dust had been carried through, during the test. The dust deposits on the collector cell as well as on the afterfilter appeared to be well saturated with oil.

An examination of the test apparatus after the test revealed that no visible traces of dust could be found in either the upstream or downstream part of the duct.

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

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THE NATIONAL BUREAU OF STANDARDS

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