NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE TEST OF A WESTINGHOUSE
"PRECIPITRON" ELECTROSTATIC AIR CLEANER

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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Building Technology Division

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1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of a Westinghouse electrostatic air cleaner were determined. The scope of this examination included determination of the arrestance of particulate matter suspended in the laboratory air and of Cottrell precipitate, pressure drop, dust holding capacity and cleanability of the specimen.

2. DESCRIPTION OF TEST SPECIMEN

The air cleaner was manufactured and supplied by the Westinghouse Electric Corporation, Sturtevant Division, of Boston, Massachusetts, and was designated "Precipitron". The collector cell was identified as the manufacturer's type CB 2025, serial #496D151G04, the power pack was type RC5, serial #S496D519G01. The manufacturer also furnished an adhesive "Dustic Type B" which was applied to the test specimen as directed.

The collector cell assembly was mounted in a sheet steel housing. It was provided with a lint screen, Farr type #5706, as a prefilter, and a Farr type #5611 after-filter. The lint screen consisted of a single 8-mesh wire screen installed in a U-shaped steel frame. The after-filter was similar to the Farr type 44, 1 in. thick. The outside measurements of the collector cell were 24 1/2" x 19 3/4" and were the same as that of the prefilter and after-filter. The face dimensions of the cell were 18 3/8" x 22 1/8". It contained 117 plates, each measuring 19 1/2" x 5"; or 158 sq ft total plate surface. The collector plates were 0.020 in. thick and spaced approximately 0.192 in. on center. The unit was equipped with 11 ionizer wires and grounded separators which consisted of 2 1/2" x 1/8" metal strips. The cell housing was provided on either side with a transition piece for adapting it to the NBS test apparatus. The manufacturer had rated the filter for an air flow of 1740 cfm which corresponded to a net face velocity of 615 ft/min, based on a

net inlet area of 2.82 sq ft after deducting the area taken up by the plates, or to a gross face velocity of 518 ft/min, based on the 3.36 sq ft area of the face of the collector cell.

3. TEST METHOD AND PROCEDURE

Arrestance determinations were made by the NBS "Dust Spot Method" using the following aerosols: (a) the particulate matter in the laboratory air 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).

The sampling air was drawn from the center points of the test duct one foot upstream and eight feet downstream of the air cleaner assembly at equal flow rates and passed through known areas of Whatman No. 41 filter paper. For determining the arrestance with the particulate matter in the laboratory air, the samples were drawn at equal rates for periods of one hour to 3 1/2 hours, depending on the dustiness of the outdoor air. In order to obtain a similar increase of opacity on the upstream and downstream sampling papers, an upstream sampler area of 0.884 sq in. and a downstream area of 0.3533 sq in. were selected and an electric timer that operated two solenoid valves in the sampling line was set to pass the sampling air through the upstream sampler only 20 percent of the time using a five minute cycle, while bypassing the sampler the rest of the time. The downstream sampling air was drawn through the sampling paper all of the time. The resultant arrestance A (in percent) was then computed by the following formula:

$$A = \left(1 - \frac{0.3533}{0.844} \times 0.20 \times \frac{\Delta D}{\Delta U}\right) \times 100$$

where ΔD and ΔU were the observed values of the change in opacity of the downstream and upstream samplers, respectively. Under these conditions, an arrestance of 92.0 percent would have been indicated if the dust spots on the upstream and downstream sampling papers had shown the same change of opacity. The change of opacity was determined with a sensitive light transmission photometer which measured the same areas on the sampling papers before and after the tests. The two filter papers used for each test were selected to have the same light transmission readings when clean.

For determining the arrestance with Cottrell precipitate, an upstream dust spot area of 2.685 sq in. and a downstream area of 0.2651 sq in. were selected. Two filter papers were used successively in the upstream sampler and each operated during the dispersion of 10 grams of dust into the test apparatus, whereas only one sampling paper was used in the downstream sampler for the total 20 grams. All three sampling papers were selected for equal light transmission when clean. If ΔU_1 and ΔU_2 are the changes of the opacity of the two upstream papers the resulting arrestance then was:

$$A = \left(1 - \frac{0.2651}{2.685} \times \frac{\Delta D}{\Delta U_1 + \Delta U_2}\right) \times 100$$

Under this condition, an arrestance of 95.06 percent would have been indicated if all three sampling papers had shown the same change of opacity.

The power pack was connected to the 115-volt A.C. laboratory power supply through a variable transformer, the output voltage of which was maintained at 120 ± 2 volts during the operation of the test specimen. When the ionizer and plate voltages were measured with a sensitive electrostatic kilovolt meter tne input to the power pack was adjusted to 120 ± 1/4 volts. The high voltage current could be observed on a milliammeter 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 apparatus, the housing was carefully sealed to eliminate air leakage. It was then determined that the ionizer and plate voltages corresponded to the values recommended by the manufacturer, i.e., ionizer 11.1 KV, collector plates 5.0 KV. Two determinations of the arrestance of the clean unit were then made at the rated air flow rate of 1740 cfm and also at air flow rates of 2088 cfm and 1392 cfm (20 percent above and below the rated air flow rate, respectively). During these tests, outdoor air was drawn into the test apparatus through a nearby window and used as the aerosol.

Following these initial arrestance determinations, the arrestance of the test specimen was determined with laboratory air into which Cottrell precipitate at a concentration of one gram per thousand cubic feet was dispersed at the rated air flow rate of 1740 cfm. The loading of the filter was then begun with 4 percent of cotton lint added to each 96 percent of Cottrell precipitate, by weight, each 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 pressure. At selected intervals, as the loading progressed, arrestance determinations were made using either the laboratory air alone or laboratory air with Cottrell precipitate as the aerosol. No lint was dispersed into the test apparatus during these latter arrestance determinations, but an appropriate amount of linters was added to retain the ratio of 4 to 96, after each arrestance determination. The pressure drop across the test specimen, and the ionizer and plate voltages were recorded at intervals during the test. The test was to be discontinued after 1160 grams of Cottrell precipitate and lint (i.e., 2/3 gram per cfm of rated air flow) had been dispersed into the test apparatus or when the pressure drop had reached 1 in. W.G.

The cleanability of the filter cell, prefilter and after-filter was determined after they were removed from the test apparatus. A stream of cold water from a high pressure hose nozzle was used for cleaning all three components.

4. TEST RESULTS

The test results have been summarized in Table 1 which shows the air flow rates at which the unit was operated, the cumulative dust loads, the ionizer and plate voltages and their combined current, the pressure drops across the unit and the arrestance values determined with the particulate matter of the laboratory air as the aerosol and with Cottrell precipitate.

A maximum of about three audible discharges per minute occurred when Cottrell precipitate was dispersed into the test apparatus. No discharges were noticed while the test specimen was operated with laboratory air only.

Table 1

Performance of Westinghouse Precipitron

Air Flow Rate cfm	Dust Load grams	Voltage Ionizer KV	Voltage Plate KV	Current ma	Pressure Drop in. W.G.	Arrestance %	Aerosol Used **
2088	0	11.1	5.0	1.2	0.300	91.4*	A
1740	0	11.1	5.0	1.2	0.208	95.7*	A
1392	0	11.1	5.0	1.2	0.147	97.7*	A
1740	20	11.05	5.0	1.2	0.210	99.5	B
1740	228	11.05	5.0	1.2	0.311	95.1	A
1740	415	11.1	5.0	1.15	0.738	99.1	B
1740	415	11.1	5.0	1.15	0.744	93.7	A
1740	435	11.1	5.0	1.15	1.02	93.5*	A

* Average of two tests.

** A = Particulate matter in laboratory air.

B = Cottrell precipitate in laboratory air.

5. SUMMARY

A. Performance

At the rated air flow rate of 1740 cfm (615 ft/min net face velocity) the arrestance of particulate matter in the laboratory air was 95.7 percent, before any Cottrell precipitate had been dispersed into the test apparatus. When the air flow rate was increased by 20 percent to 2088 cfm the arrestance dropped 4.3%, to 91.4 percent. Under the same conditions, it increased 2%, to 97.7 percent when the air flow rate was decreased by 20% to 1392 cfm. Subsequent to this series of tests the unit was operated only at the rated air flow rate of 1740 cfm. It was found that the arrestance of atmospheric dust decreased to 93.5 percent when the dust load reached 435 grams and the pressure drop had gone up to 1.02 in. W.G.

Two tests made with Cottrell precipitate as the aerosol showed 99.5 percent and 99.1 percent arrestance. The high voltage measurements remained practically constant throughout the test.

The pressure drop at 1740 cfm air flow rate was 0.208 in. W.G. when the unit was clean and increased to 1.02 in. W.G. when a dust load of 435 grams was dispersed into the test apparatus. A layer of lint approximately 1/4 in. thick covering the lint screen may have produced a considerable portion of the pressure drop increase. The total load was only 1/4 gram per cfm of rated air flow when the pressure drop reached the limiting value of 1 in. W.G. It was not determined whether the relatively rapid increase in pressure drop was due primarily to the lint accumulation on the prefilter or the close spacing of the plates in the collector cell or a combination of these two factors.

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, the lint screen or the after-filter 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 heaviest deposits were observed on the leading edges of the negative plates where the layers were estimated to be about 1/32 in. thick. Only very small lint particles were noticed on the surface of the collector cell but the after-filter had a solid cover of lint on its front side. The back side of the after-filter was completely clean and did not indicate that dust had been carried through during the test. The dust deposits on the collector plates as well as on the after-filter 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 test apparatus.

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U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, Acting Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

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WASHINGTON, D.C.

Electricity and Electronics. Resistance and Reactance. Electron Devices. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Engine Fuels. Free Radicals Research.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Physics. Radiation Theory. Radioactivity. X-rays. High Energy Radiation. Nucleonic Instrumentation. Radiological Equipment.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

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Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

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- Office of Basic Instrumentation.
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BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio-Meteorology. Lower Atmosphere Physics.

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