NATIONAL BUREAU OF STANDARDS REPORT

7043

PERFORMANCE TEST OF A HIGH-VELOCITY
ELECTROSTATIC AIR CLEANER, MODEL HV-1

Manufactured by
Dollinger Corporation
Rochester, New York

by

C. W. Coblentz and P. R. Achenbach

Report to

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

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NBS PROJECT		NBS REPORT
1003-30-10630	December 19, 1960	7043

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C. W. Coblentz and P. R. Achenbach
Mechanical Systems Section
Building Research Division

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1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of a high-velocity electrostatic precipitator, Model HV-1, manufactured by the Dollinger Corporation of Rochester, New York, were determined. The scope of this examination included the determination of the arrestance of the particulate matter in the laboratory air and of Cottrell precipitate, the pressure drop, and the dust-holding capacity of the specimen.

2. DESCRIPTION OF TEST SPECIMEN

The device was manufactured and supplied for test purposes by the Dollinger Corporation of Rochester, New York. The test specimen was described as a "high-velocity cell."

The outside dimensions of the collector cell were 20 in. high by 23 in. wide, and 22 3/4 in. deep; the inside air passage measured 18 1/4 in. by 21 3/4 in. corresponding to a gross face area of 3.20 sq ft and a net face area of 2.76 sq ft for the cell. The collector plates were made of aluminum sheet 0.0343 in. thick and measured 18 1/2 in. by 16 in. with eleven 18 1/2 by 18 1/2 plates extended to furnish the struds between the ten ionizer wires. The plates were spaced 5/16 in. center-to-center.

The 100-watt power pack had two high voltage terminals of equal but opposite polarity. The positive terminal was connected to the ionizer wires and the negative terminal to the group of collector plates which included the struds between the ionizer wires. The alternate collector plates were grounded. The cell was equipped with a cleanable viscous impingement type after-filter, Air-Maze Corporation Type P-5, measuring 23 in. by 19 3/4 in. by 1 7/8 in. outside and having a net face area of 21 3/4 in. by 18 1/8 in., or 2.69 sq ft.

3. TEST METHOD AND PROCEDURE

The arrestance measurements were made in accordance with the "NBS Dust Spot Method" described in a paper by R. S. Dill and entitled "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938).

For test purposes, the collector cell was installed in the test apparatus and carefully sealed to prevent inward leakage of air except through the measuring orifice. The desired rate of air flow through the filter was established and samples of air were drawn from the center points of the test duct two feet upstream and eight feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The change of the opacity of these areas was determined with a sensitive photometer which measured the light transmission of the same spot on each sampling 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.

For determining the arrestance of the filter with Cottrell precipitate as the test dust, different size areas of sampling papers were used upstream and downstream of the filter in order to obtain a similar increase of opacity on both sampling papers. For each arrestance determination with Cottrell precipitate, the upstream sample of the aerosol was collected on one filter paper for half of the test period and on a second filter paper during the remainder of the test period. The downstream sampling paper collected the dust for the entire test. This method was used to avoid excessive differences in the dust spots when determining Cottrell precipitate arrestance values above 95 percent. The arrestance, A (in percent), was then calculated by the formula:

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

where S_U and S_D are the upstream and downstream sampling areas and ΔU_1, ΔU_2, and ΔD the observed changes in the opacity of the two upstream and one downstream sampling papers, respectively.

For determining the arrestance of the particulate matter in the laboratory air, equal sampling areas were used for the upstream and downstream samplers. A similar increase of the opacity of the upstream and downstream filter papers was obtained

by passing the sampling air through the upstream paper only part of the time while operating the downstream sampler continuously. This was accomplished by installing a solenoid valve in the upstream sampling line and using another one to by-pass the upstream sampler and first solenoid valve. The valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, reversing the position of the two valves during the remainder of the cycle. The arrestance, A (in percent), was then determined with the following formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, ΔU and ΔD being the changes of opacity of the sampling papers, as previously indicated.

After installing the device, the power pack was connected to the laboratory electric supply line and the static potentials at 115 volts input measured with an electrostatic kilovoltmeter were then 6,500 volts. By means of a variable voltage transformer, the line voltage was adjusted during subsequent readings of the static voltage to 115 volts ± 1/4 volt but was allowed to drift between readings.

Several arrestance determinations, made under this condition, using the particulate matter in the laboratory air as the aerosol, indicated that the air flow rate at which 90% arrestance was obtained had to be reduced below the design air flow rate of 1800 cfm. After consulting with the manufacturer, the static potential was raised to ± 6,850 volts, and the arrestance with atmospheric air was again determined.

Following the initial arrestance determinations with the particulate matter in the laboratory air as the aerosol, the arrestance of the device was determined with laboratory air into which Cottrell precipitate was dispersed at a rate of one gram per thousand cubic feet of air. The loading of the filter was then commenced with 4 parts lint by weight added to every 96 parts of Cottrell precipitate. The Cottrell precipitate had been previously sifted through a 100-mesh screen and the lint was prepared from No. 7 cotton linters which were ground in a Wiley mill with a 4 mm screen. Each aerosol was dispersed separately into the air stream. As the loading progressed, arrestance determinations were made at selected intervals using either the laboratory air alone or laboratory air with Cottrell

precipitate. No lint was introduced into the test apparatus during the arrestance determinations with Cottrell precipitate, but an appropriate amount of lint was added to maintain the overall ratio of 4 to 96. The pressure drop across the test specimen, the ionizer and plate voltages, and the frequency of noticeable electrostatic discharges were recorded at each arrestance determination and also after each increment of 20 grams of Cottrell precipitate had been introduced into the test apparatus.

Thirteen arrestance determinations were made during the loading period with air flow rates ranging from 1,400 to 2,200 cfm using either Cottrell precipitate or the particulate matter of the laboratory air as the aerosol. A total of 1,214 grams of Cottrell precipitate and lint were introduced into the test apparatus during the loading in conformance with the regular practice of terminating the test of such filters with a dust load of 2/3 grams for each cfm rated air flow.

4. TEST RESULTS

The test specimen had a rated air flow rate of 1,800 cfm with a gross face area of 3.20 sq ft. This corresponded to a face velocity of 563 ft/min.

A summary of the test results is presented in Table 1 and shows the air flow rates, dust load, pressure drop, and arrestance values observed with the particulate matter in the laboratory air as well as with Cottrell precipitate as the aerosol. The effect of the dust load on the pressure drop and on the arrestance of the particulate matter in the laboratory air is plotted in Figure 1 and smooth curves were fitted to the plotted points.

Table 1

Performance of the
Dollinger Corporation Electrostatic Precipitator
(at ± 6850 volts potential)

Air Flow Rate cfm	Dust Load grams	Pressure Drop in. W. G.	Arrestance %	Aerosol **
1400	0	0.116	95.1*	A
1800	0	0.183	91.1*	A
2200	0	0.257	87.8*	A
1800	12	0.183	97.8	C
1800	323	0.229	97.9	C
1800	323	0.229	90.9	A
1800	601	0.296	90.9	A
1800	974	0.399	90.5	A
1800	1202	0.508	89.0	A
1800	1214	0.513	95.4	C

* Average of two tests.

** A = Particulate matter in laboratory air.
C = Cottrell precipitate in laboratory air.

It will be noted that the arrestance of atmospheric dust at the rated air flow rate was 91.1 percent with a clean filter and 89.0 percent with a dust load of 1,202 grams. The pressure drop increased during loading from an initial value of 0.116 in. W.G. to 0.508 in. W.G. Reducing the air flow rate to 1,400 cfm increased the initial arrestance to 95.1 percent while an increase to 2,200 cfm reduced it to 87.8 percent. The average arrestance of Cottrell precipitate was 97 percent.

Table 2 shows the arrestance of the test specimen at two different static potentials giving a comparison between the initial tests at 6,500 volts and the later tests at 6,850 volts. The values are plotted in Figure 2. The arrestance at 6,500 volts was extrapolated above 1,800 cfm as a dashed line. The difference in the arrestance at the two static potentials was 1.9 percent at 1,400 cfm air flow rate; it increased to 2.2 percent at 1,800 cfm, and to approximately 2.5 percent at 2,200 cfm.

Table 2

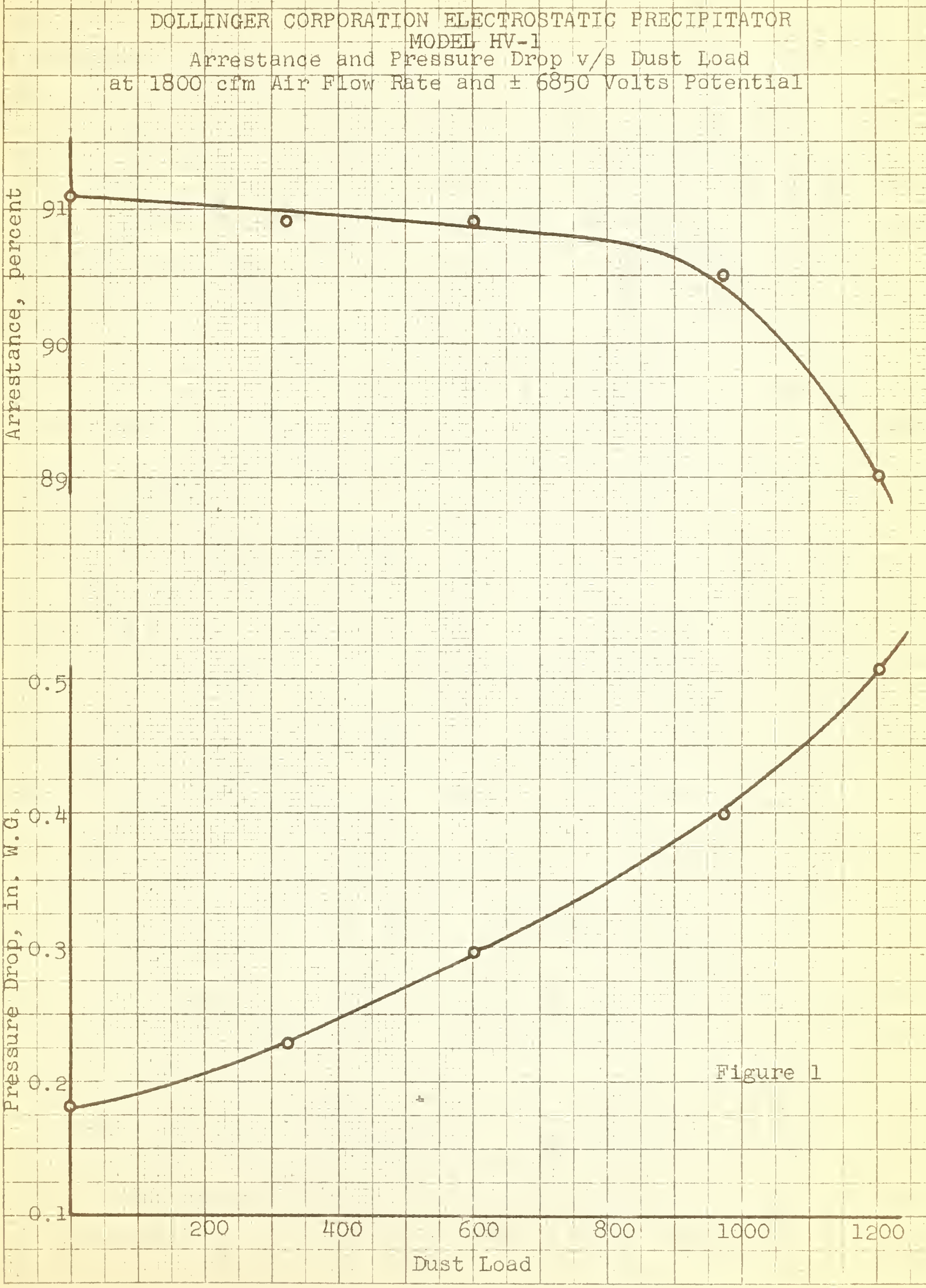
Arrestance at Reduced Static Potential

Air Flow Rate, cfm	1400	1800	2200
6,500 volts	93.2	88.9	85.2*
6,850 volts	95.1	91.1	87.8

* extrapolated from Figure 2.

An examination of the collector cell at the conclusion of the test showed that all plates were about evenly covered with a light layer of dust. The after-filter and the collector cell were washed with water and no difficulty was encountered in cleaning out the dust that had accumulated during the test.

The number of electrical discharges between plates observed during the tests reached, at one time, 19 per minute but it was considerably less during most of the test and no discharges at all were noticed during about half of the operating time.



DOLLINGER CORPORATION ELECTROSTATIC PRECIPITATOR
MODEL HV-1
Arrestance and Pressure Drop v/s Dust Load
at 1800 cfm Air Flow Rate and ± 6850 Volts Potential
Arrestance, percent
91
90
89
Pressure Drop, in. W.G.
0.5
0.4
0.3
0.2
0.1
200
400
600
800
1000
1200
Dust Load

Figure 1

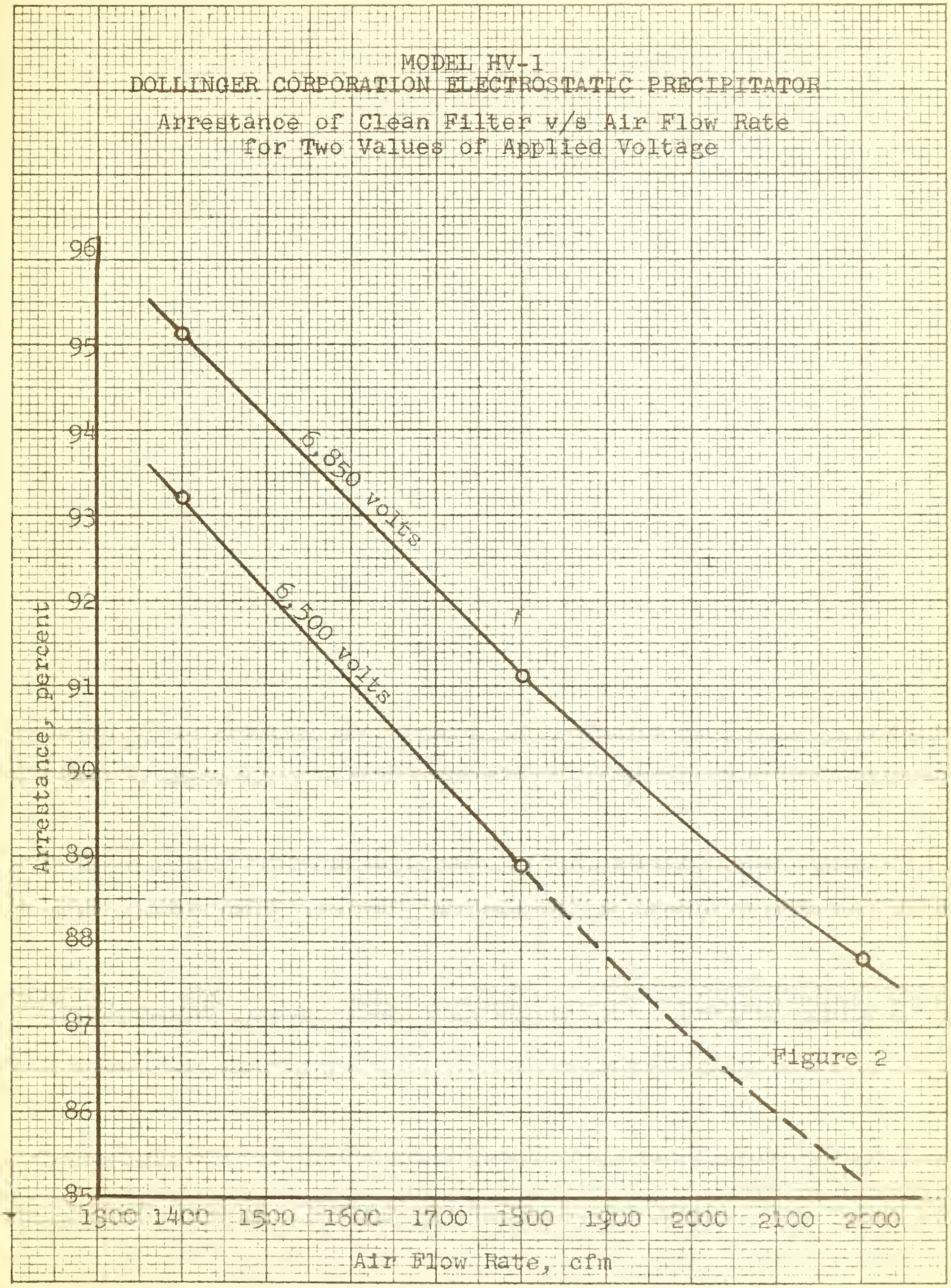

MODEL HV-1
DOLLINGER CORPORATION ELECTROSTATIC PRECIPITATOR
Arrestance of Clean Filter v/s Air Flow Rate
for Two Values of Applied Voltage
Arrestance, percent
96
95
94
93
92
91
90
89
88
87
86
85
6,850 volts
6,500 volts
1300
1400
1500
1600
1700
1800
1900
2000
2100
2200
Air Flow Rate, cfm

Figure 2

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

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

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colo., is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D.C.

ELECTRICITY. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics.

METROLOGY. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

HEAT. Temperature Physics. Heat Measurements. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectroscopy.

RADIATION PHYSICS. X-Ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

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

MECHANICS. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. 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.

MINERAL PRODUCTS. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

BUILDING RESEARCH. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials.

APPLIED MATHEMATICS. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

DATA PROCESSING SYSTEMS. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

ATOMIC PHYSICS. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics.

INSTRUMENTATION. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

IONOSPHERE RESEARCH AND PROPAGATION. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services.

RADIO PROPAGATION ENGINEERING. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmosphere Physics.

RADIO STANDARDS. High frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time Standards. Electronic Calibration Center. Millimeter-Wave Research. Microwave Circuit Standards.

RADIO SYSTEMS. High Frequency and Very High Frequency Research. Modulation Research. Antenna Research. Navigation Systems. Space Telecommunications.

UPPER ATMOSPHERE AND SPACE PHYSICS. Upper Atmosphere and Plasma Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

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