NATIONAL BUREAU OF STANDARDS REPORT

6947

PERFORMANCE TESTS OF A
"ROLL-O-MATIC" AUTOMATIC RENEWABLE MEDIA AIR FILTER

manufactured by
American Air Filter Company
Louisville, Kentucky

by

C. W. Coblentz and P. R. Achenbach

Report to

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

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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NBS PROJECT		**NBS REPORT**
1003-30-10630	August 25, 1960	6947

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Carl W. Coblentz and Paul 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 an American Air Filter Company "Roll-O-Matic" air filter were determined. The scope of this examination included determinations of the arrestance of the particulate matter in the laboratory air and Cottrell precipitate at the rated air flow, the dust-holding capacity of the filter medium per unit area, observation of the automatic advance of the filter mat, and determination of the pressure drop for a range of air flow rates and during the loading process at the rated air flow.

2. Description of Test Specimen

The test specimen was manufactured and supplied in the size required for test purposes by the American Air Filter Company, Inc., of Louisville, Kentucky, and identified by the trade name "Roll-O-Matic." It was intended to be representative of the equipment offered commercially in larger sizes.

The filter medium was a fiber glass mat about 2 1/4 in. thick reinforced on the downstream side by longitudinal wires. The glass fibers appeared to be bonded by an organic plastic material and were covered with tricresyl phosphate as an adhesive. The mat was supplied in a 3-ft wide roll on which it was compressed to approximately 1/2-in. thickness. The clean roll was suspended in the upper part of the housing, and after passing the 24-in. square air flow opening, was rolled up on another spool at the bottom of the housing by an electric motor. In passing from the clean roll at the top of the housing to the bottom roll, the medium was backed up by a vertical stationary grid that prevented excessive deflection of the filter mat when passing across the air flow opening.

The movement of the blanket by the electric motor was controlled by a time switch and a pressure switch which were arranged to override each other. The time switch advanced the filter mat at the minimum rate required to prevent the filter from drying out and reducing the ability to arrest the particulate matter. The pressure switch would activate the advance mechanism when the pressure drop across the filter media had increased to a pre-set value before the time switch had moved the media. The advance of the filter mat would then continue until the pressure drop had decreased by about 0.1 in. W.G. The specimen was designed to operate on the time switch, and the pressure switch had been added as a safety device to avoid overloading of the filter media during temporary extreme dust loads.

There was also an inclined gage arranged parallel to the pressure switch that showed the difference of the total air pressures upstream and downstream of the filter.

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 housing with the filter medium in place 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. The arrestance, A (in percent), was then

calculated by the formula:

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

where S_U and S_D are the upstream and downstream sampling areas and ΔU and ΔD the observed changes in the opacity of the upstream and 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 then 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 one solenoid valve in the upstream sampling line and another one as a by-pass. 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.

The pressure drop of an automatic renewable media air filter of this type increases during operation with the media in a stationary position, due to the accumulating dust load, until it reaches the value at which the pressure switch was set to operate the advance mechanism. The test was conducted without the use of the time switch and the pressure switch was set to commence advance at a value a little below 0.5 in. W.G. The differential pressure was not adjustable.

When clean media was moved into the air stream, the pressure drop decreased until the pressure switch stopped the advance drive. The filter operated repetitively in the on-off range of the pressure switch, the differential controlling the length of clean blanket that was moved into the air stream and the rate of dust accumulation determining the

frequency of the cycles. The operation of this type filter at a higher pressure drop would increase the dust load per unit area of the filter medium. The saving on filter material, however, would tend to be offset by the increase of the required blower power. The selected maximum pressure drop of 0.5 in. W.G. corresponds to common operating practice for this type of filter.

The following procedure was used for determining the performance of the test specimen: The pressure drop of the clean filter mat was determined at the rated face velocity of 500 ft/min, corresponding to an air flow rate of 2000 cfm, and also at air flow rates of 20 percent above and below this value, i.e., 2400 cfm and 1600 cfm. Thereafter, the specimen was operated only at the rated face velocity, and three arrestance determinations were made using the particulate matter in the laboratory air as the aerosol, followed by two further arrestance measurements with Cottrell precipitate, after which the loading of the filter with a mixture of 96 parts by weight of Cottrell precipitate and 4 parts of lint was started. The Cottrell precipitate had previously been sifted through a 100-mesh screen and was dispersed into the test apparatus in a ratio of 1 gram per 1000 cu ft of air. The lint was introduced into the air stream separately and was prepared by grinding No. 7 cotton linters through a Wiley mill with a 4-millimeter screen.

Several more arrestance determinations were made later when the blanket had advanced several steps using both aerosols. The distance of each advance of the filter media was observed by means of small markers fastened to the mat. These markers moved alongside a yardstick mounted in the filter housing and could be observed through a glass window in the test duct. A pilot light was installed parallel to the advance motor and enabled the operator to record the pressure drop of the test specimen at the start and at the end of each advance of the filter mat. The test was terminated when the media had advanced 32 1/2 in. At that time, a total of twelve arrestance determinations had been made in addition to the five made initially with the clean filter mat.

4. Test Results

The test results are summarized in Tables 1 and 2 and shown as graphs in Fig. 1 and 2. Table 1 gives the observed values for dust load, total mat travel, pressure drop, and the arrestance values determined with the particulate matter in the laboratory air and with Cottrell precipitate.

Table 1

Summary of Arrestance, Pressure Drop, and
Mat Travel Determinations at Rated Air Flow
American Air Filter Co., "Roll-O-Matic" Air Filter

Dust Load g/ft width	Total Mat Travel inches	Pressure Drop in. W. G.	Arrestance %	Aerosol **
0	-	0.103	18*	A
10	-	0.113	71*	C
223	-	0.296	77	C
410	-	0.438	18	A
669	10 1/2	0.415	77	C
943	19 1/2	0.454	79*	C
943	19 1/2	0.454	30*	A
1099	28	0.371	28	A
1104	28	0.373	78	C
1218	32 1/2	0.366	78*	C

* Average values of two or more tests.

** Aerosol A - Particulate matter in the laboratory air.
Aerosol C - Cottrell precipitate in the laboratory air.

Table 2

Mat Travel, Dust Load, and Pressure Drop
Before and After Advance of Filter Media
American Air Filter Co., "Roll-O-Matic" Air Filter
at Rated Face Velocity of 500 ft/min

Dust Load	Travel of Mat, in.		Pressure Drop, in. W.G.	
g/ft width	Advance	Total	Before Advance	After Advance
0	0	0	0.103	-
488	4	4	0.490	0.422
550	2 1/2	6 1/2	0.490	0.410
612	4	10 1/2	0.488	0.365
716	4 3/4	15 1/4	0.472	0.362
851	4 1/4	19 1/2	0.487	0.363
975	4	23 1/2	0.480	0.365
1089	4 1/2	28	0.478	0.361
1213	4 1/2	32 1/2	0.472	0.364

The dust load is reported in grams per foot width, referring to the 2-ft square air flow opening. At the end of the test, 1218 g/ft width of Cottrell precipitate and lint had been introduced into the test apparatus, corresponding to a total weight of 2436 grams. No fallout of dust could be found in the test duct at the termination of the test.

The average arrestance of the particulate matter in the laboratory air varied from 18 percent to 30 percent. The lowest values were determined when the filter medium was clean. After the filter mat had once started to advance, the values of 28 and 30 percent were observed.

The arrestance values with Cottrell precipitate determined on the clean filter mat were 72 percent and 71 percent and varied between 77 and 79 percent after regular advance of the filter media began. The average arrestance with Cottrell precipitate was 78 percent at steady state conditions.

The pressure drop of the clean filter mat at different air flow rates is shown as follows in Table 3.

Table 3

Pressure Drop of Clean Filter

Air Flow Rate cfm	Face Velocity ft/min	Pressure Drop in. W. G.
2400	600	0.132
2000	500	0.103
1600	400	0.077

The dust load values presented in Table 2 are the cumulative weight of dust and lint, in grams per foot width, that had been introduced into the test apparatus at the beginning of each advance of the filter medium. The values are interpolated between the 20-gram increments of Cottrell precipitate and are correct to within ± 3 grams. The mat travel during the advance varied from 2 1/2 in. to 4 3/4 in. It appears that the first two advance cycles did not represent steady state operation of the specimen since the dust load increments after these two advances were only about one half as large as for the later advances of the media. Since the positions of the markers which indicated the travel distance of the mat

could not be observed much closer than ± 1/2 in., it can be assumed that the advance distance during the six cycles that followed the two initial cycles were practically equal. This fact is also indicated by the nearly-constant values of the pressure drop observed at the beginning and at the end of each advance; namely, 0.481 in. W.G. ± 0.009, and 0.363 in. W.G. ± 0.002, respectively.

The amount of Cottrell precipitate collected on a unit area of filter medium during the steady state operation of the test specimen provides a measure of the rate of consumption of the media during actual use. Disregarding the insignificant mass of particulate matter collected on the filter during the arrestance determinations with laboratory air, the dust-holding capacity per unit area is expressed by the slope of the straight line in Fig. 2 that best fits the individual points of observation. According to this line, there were 1196 - 646 = 550 g/ft width of dust and lint introduced into the filter mat while the filter mat advanced from the 12-inch to the 32-inch position, a distance of 20 inches. Therefore, the dust-holding capacity, then, was

$$\frac{550 \times 12}{20} = 330 \text{ g/sq ft.}$$

Table 4 below presents a summary of the performance data of this filter.

Table 4

Summary of Test Results

Face Velocity, rated - 500 ft/min

Pressure Drop, clean
- at 400 ft/min face velocity - 0.077 in. W.G.
- at 500 ft/min face velocity - 0.103 in. W.G.
- at 600 ft/min face velocity - 0.132 in. W.G.

Average range of operating pressure - 0.481 to 0.363 in. W.G.

Arrestance, average
- Mat clean, laboratory air - 18%
  - Cottrell precipitate - 71%
- Steady state, laboratory air - 29%
  - Cottrell precipitate - 78%

Dust-Holding Capacity - 330 g/sq ft.

ARRESTANCE v/s DUST LOAD

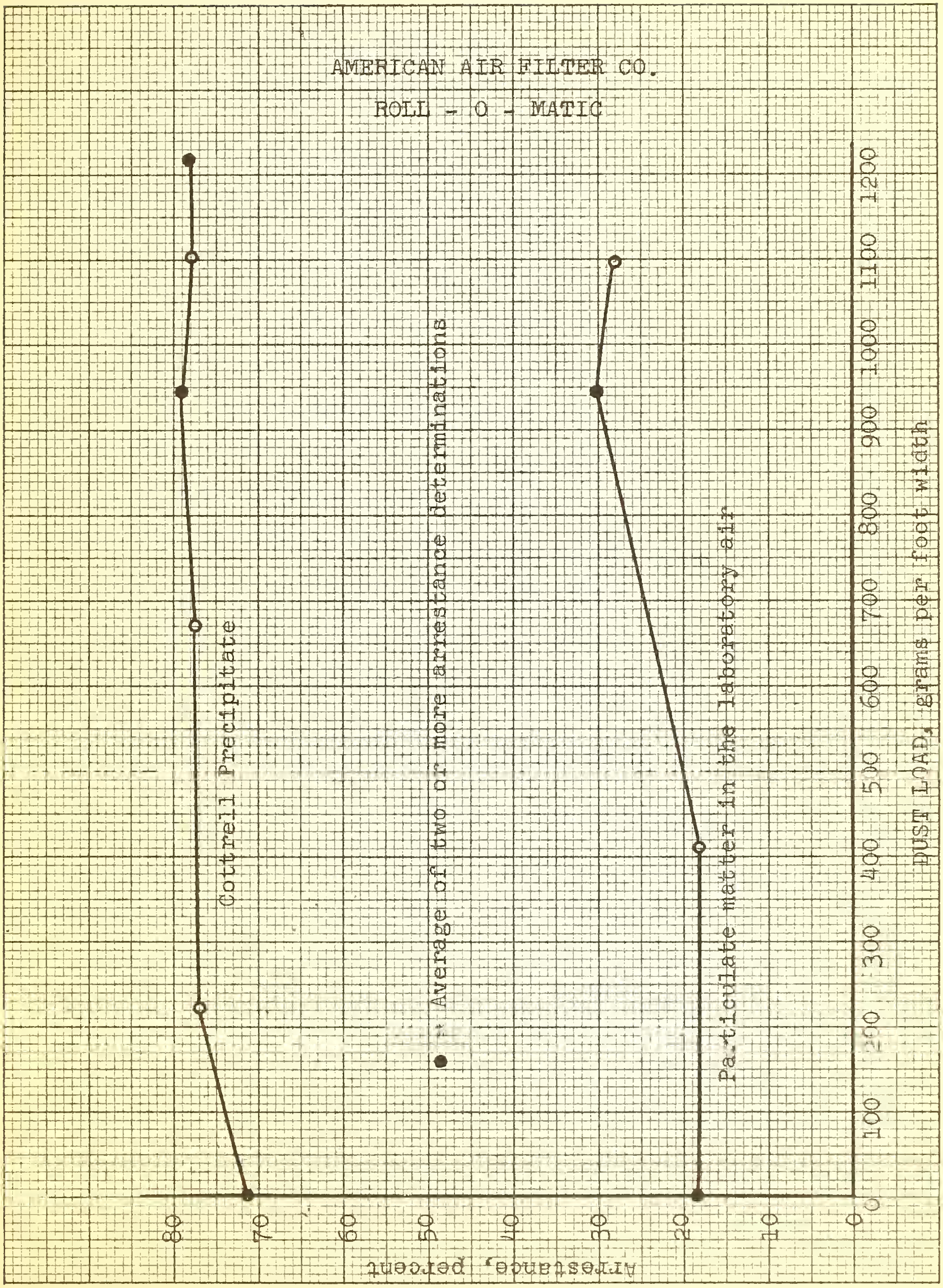

Figure 1

MAT TRAVEL v/s DUST LOAD

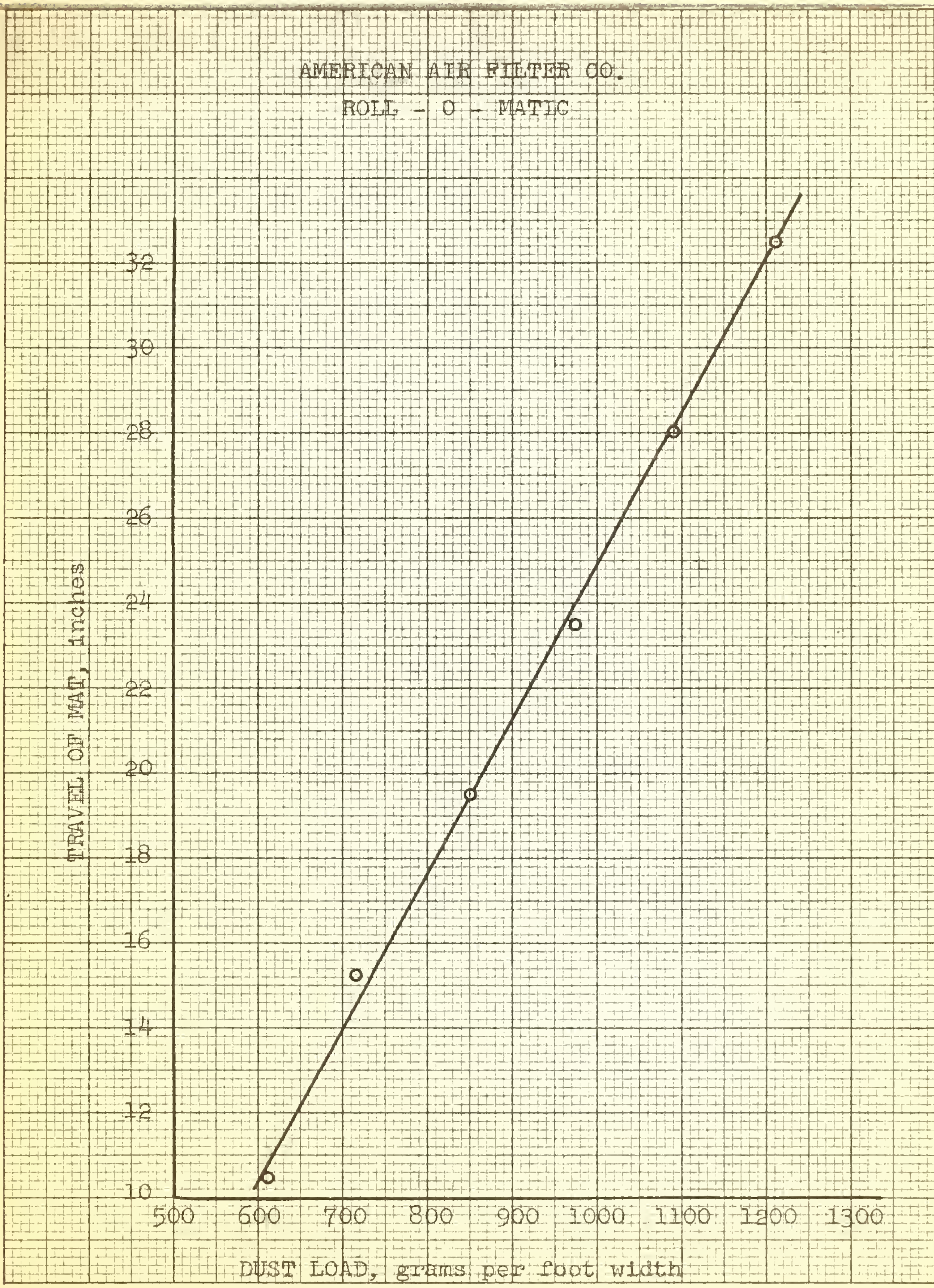

Figure 2

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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. Photographic Technology. Length. Engineering Metrology.

Heat. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology. Molecular Kinetics. 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.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

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

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Application Engineering.

• Office of Basic Instrumentation.

• Office of Weights and Measures.

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 Research. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation Obstacles Engineering. Radio-Meteorology. Lower Atmosphere Physics.

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