NATIONAL BUREAU OF STANDARDS REPORT

6692

PERFORMANCE TESTS OF TWO THROW-AWAY TYPE "DUST-STOP" AIR FILTERS

Manufactured by
Owens-Corning Fiberglas Corporation
Toledo, Ohio

by

Carl W. Coblentz
and
Paul R. Achenbach

Report to

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

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Carl W. Coblentz and Paul R. Achenbach
Air Conditioning, Heating, and Refrigeration Section
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1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of two specimens of the throw-away type "Dust-Stop" air filters, 1-inch thick, were determined. The scope of this investigation included the determination of the arrestance of Cottrell precipitate and of the particulate matter in the laboratory air, the dust holding capacity and the pressure drop at 370 ft/min face velocity. The pressure drop across the clean filter for a range of face velocities was also measured.

2. DESCRIPTION OF TEST SPECIMENS

The test specimens were manufactured by the Owens-Corning Fiberglas Corporation of Toledo, Ohio, and bore the trade name, "Dust-Stop." They were supplied by the manufacturer. The nominal size of the filter was 20 x 20 x 1 inches; the actual size was 19 5/8 x 19 5/8 x 15/16 inches with a net face area of 17 7/8 inches square, i.e. 2.22 sq ft. The filter media consisted of a pack of glass fibers which were treated with an oily adhesive and were supported on both faces by thin brass sheet retainers, perforated with 1 1/2 inch diameter cut-outs. The retainers and media were held together with cardboard frames. Each filter weighed 377 grams (13.3 oz). The two specimens were of the same design and supposedly identical in construction.

3. TEST METHOD AND PROCEDURE

The performance of the test specimens was determined at a face velocity of 370 ft/min or 822 cfm. The arrestance measurements were conducted in accordance with the NBS "Dust-Spot Method" described in a paper entitled, "A Test Method for Air Filters" by R. S. Dill, (ASHVE Transactions, Vol. 44, p. 379, 1938).

For testing, each filter was installed in the test apparatus and carefully sealed to prevent inleakage 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 bypass. 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 halves 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.

At the conclusion of the test of each specimen, the fall-out of dust that occurred upstream of the filter was determined by sweeping out this part of the test apparatus. The dust load was then calculated as the average amount of dust and lint that reached the filter per unit area, i.e. the weight that was introduced into the test apparatus divided by the net face area of the filter and multiplied by the fraction of the total dust introduced into the apparatus at the termination of the test that reached the filter, according to the formula:

$$D = \frac{D_O}{A} \times \frac{D_T - F}{D_T}$$

where: D = Dust load of the filter at the time when D_O grams of dust have been introduced into the test apparatus, g/sq ft

D_T = Total dust introduced into the test apparatus during the test, grams

F = Dust fall-out in the upstream portion of the test apparatus at the end of the test, grams

A = Net face area of filter, sq ft

At the end of the test, when $D_O = D_T$,

$$D^1 = \frac{D_T - F}{A}$$

Before introducing test dust, the pressure drop of the first test specimens was determined at five different air flow rates from 411 cfm to 1233 cfm, i.e. at the rated air flow rate and 25% and 50% above and below this flow. Thereafter, two determinations of the arrestance of the particulate matter in the laboratory air were made, followed by two arrestance determinations with Cottrell precipitate.

The Cottrell precipitate had been sifted through a 100-mesh screen to remove particles larger than 150 micron size. During the loading of the test specimen, lint was introduced into the test apparatus in a ratio of 4 parts to 96 parts of Cottrell precipitate, by weight. The lint was prepared from #7 cotton linters by running these through a Wiley mill with a 4 mm screen.

Cottrell precipitate was introduced into the test apparatus at a rate of 1 gram per 1000 cu ft of air.

Arrestance determinations with Cottrell precipitate were repeated after the introduction of each increment of approximately 80 grams of dust and lint until the pressure drop across the filter reached 0.5 in. W.G. At this time, two more arrestance determinations were made using the particulate matter in the laboratory air as the aerosol. The test on the first specimen was then terminated and the second specimen was installed in the test apparatus. The arrestance of this filter was determined only with Cottrell precipitate and the test was conducted in a similar manner, except that arrestance determinations were made at longer intervals.

4. TEST RESULTS

The performance of the test specimens is summarized in Tables 1 and 2 showing the dust load, the pressure drop and the arrestance of Cottrell precipitate and also of the particulate matter in the laboratory air at the rated face velocity of 370 ft/min, corresponding to an air flow rate of 822 cfm.

Table 1

Performance of Specimen 1, "Dust-Stop" Throw-Away Filter

Load g/sq ft	Pressure Drop in. W. G.	Arrestance %
0	0.080	8*A
5	0.088	58*
28	0.136	59*
59	0.187	58*
93	0.237	58
134	0.317	57
192	0.451	61
197	0.470	--
206	0.500	--
210	0.501	55*
212	0.503	4*A

* Average arrestance of two determinations.

A/ The particulate matter in the laboratory air was used as the aerosol, Cottrell precipitate was the test dust in all other tests.

Table 2

Performance of Specimen 2, "Dust-Stop" Throw-Away Filter

Load g/sq ft	Pressure Drop in. W. G.	Arrestance %
0	0.080	--
5	0.083	57*
72	0.198	57
111	0.249	--
170	0.351	61*
205	0.449	--
225	0.508	60

* Average arrestance of two determinations.

The pressure drop of each filter when clean was 0.080 in. W.G. and increased to 0.5 in. W.G. after a dust load of slightly over 200 g/sq ft had been attained. Figure 1 is a graphical presentation of these two tables and shows that the pressure curves of the two specimens agree at the lower values. It will be noted that the pressure curve of filter #1 appears to flatten significantly when a pressure drop of 0.5 in. W.G. was reached coincidental with a sharp drop of the observed arrestance, indicating that, at that time, dust was probably carried through the filter medium.

The arrestance of the particulate matter in the laboratory air determined for the first test specimen was 8 percent when the filter was clean and 4 percent when the filter was loaded. This decrease of arrestance also suggests that dust was pulled off the filter at that time, because the arrestance of such filters for atmospheric dust is usually higher when loaded than initially.

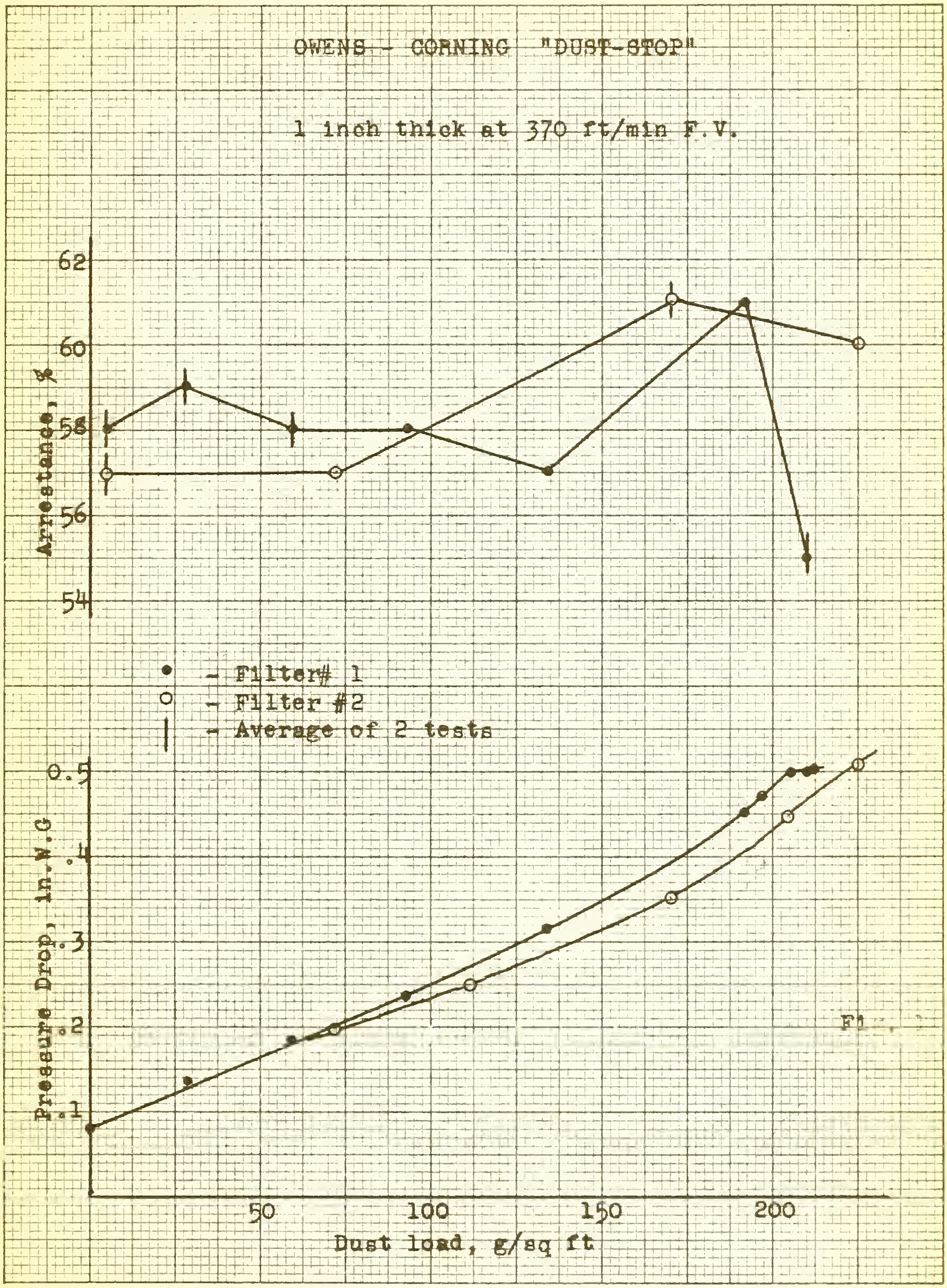
The relation of face velocity to pressure drop for the clean filter is shown in Table 3.

Table 3

Pressure Drop at Different Air Flow Rates,
"Dust-Stop" Throw-Away Filter

Air Flow Rate cfm	Face Velocity ft/min	Pressure Drop in. W. G.
411	185	0.027
617	277	0.051
822	370	0.080
1028	463	0.126
1233	555	0.157

It was noticed at the termination of each test that the filter media had forced away from the upstream grid a distance of approximately 2 inches at the center of the test specimens.


OWENS - CORNING "DUST-STOP"
1 inch thick at 370 ft/min F.V.
Arrestance, %
62
60
58
56
54
- Filter# 1
- Filter #2
- Average of 2 tests
Pressure Drop, in.W.G
0.5
.4
.3
.2
.1
50
100
150
200
Dust load, g/sq ft

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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.

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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.

Radio Standards. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Electronic Calibration Center. Microwave Physics. Microwave Circuit Standards.

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