NATIONAL BUREAU OF STANDARDS REPORT

6214

PERFORMANCE TESTS OF AN EXPANSIBLE FIBROUS MEDIA AIR FILTER,
FLANDERS EXPANSIBLE, NO. 15

MANUFACTURED BY
FLANDERS FILTERS, INC.
RIVERHEAD, NEW YORK

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

THE NATIONAL BUREAU OF STANDARDS

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Carl W. Coblentz and Paul R. Achenbach
Air Conditioning, Heating, and Refrigeration Section
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 Flanders expansible dust filter were determined using the NBS Dust Spot Method of testing. The scope of this investigation included determination of the arrestance of atmospheric dust and Cottrell precipitate, pressure drop, and dust holding capacity of the test specimen and how these characteristics were affected by the expansible feature of the filter.

2. Description of Test Specimen

The filter was manufactured and supplied for test purposes by Flanders Filters, Inc., of Riverhead, New York; it was identified as "Expansible Filter No. 15".

The filter pack consisted of a stack of 1/2 inch thick fiberglas blankets perforated in a checkerboard pattern. It was approximately 6 in. thick initially and could be compressed to about one half this thickness with the mechanism provided. In order to increase the effective filtering area of the media, each layer of the glass fiber, except the first and last, was perforated by 121 holes 1-1/2 inches square in a regular checkerboard pattern. A wall of glass fiber 1/2 inch thick separated adjacent holes in each direction. The upstream layer of glass fiber was perforated with 61 holes and the downstream layer was perforated with 60 holes of the same size as those in the other layers, but so spaced that alternate holes in the checkerboard pattern were blocked at the upstream and downstream sides of the filter pack by these surface layers. Thus, a glass fiber filter media 1/2" thick was provided when the filter was fully expanded with filtration occurring as the air passed through the walls between adjacent holes or through the upstream and downstream layers where they covered the square holes. The face of the filter pack measured 23" x 23" corresponding to a face area of 3.67 sq ft. The effective filter area provided by the channels was approximately 7 sq ft when the filter pack was fully compressed and 14.5 sq ft with the media fully expanded.

By expanding the filter suddenly when a certain pressure drop had been produced by the accumulated dust load, the designer of this filter claimed that the surface layer of dust was broken up and carried deeper into the filter medium, thus reducing the pressure drop caused by the dense surface load.

The expansion of the filter pack was controlled by a pressure switch that sensed the pressure drop across the filter and operated a small 1RPM electric motor which in turn released, by one notch at a time, the **springs** that compressed the filter pack. A signal light was provided to indicate the need for replacing the filter pack when the maximum pressure drop had been reached after the medium had been fully expanded. The filter pack was installed in a steel frame, which also supported the expansion mechanism, and could be easily replaced.

For this test, a signal light was installed, parallel with the pressure switch, to indicate the operation of the electric motor that performed the expansion of the filter pack.

3. Test Method and Procedure

Arrestance determinations were made with the NBS "Dust Spot Method" using the following aerosols: (a) air drawn from 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 this test, the unit was installed in the test duct 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 one foot upstream and eight feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The ratios of the upstream and downstream filter paper areas were selected to obtain a similar increase of opacity, and with air drawn through both samplers for the full period, the arrestance was computed by the following formula:

$$A = 100 - \left[\frac{A_D}{A_U} \times \frac{\Delta D}{\Delta U}\right] \times 100$$

where A_D and A_U are the downstream and upstream filter paper areas and ΔD and ΔU the respective changes in opacity of the samplers.

Each test with atmospheric dust required from one to two hours and, in order to make the increase of opacity of the two samplers more nearly equal, the upstream sampling air was drawn through the sampler for only part of the time. If "T" is the percentage of the time during which air was drawn through the upstream sampler while air through the downstream sampler was drawn continuously, the formula for computing arrestance would be:

$$A = 100 - \left[T \times \frac{A_D}{A_U} \times \frac{\Delta D}{\Delta U}\right] \times 100$$

The two filter papers used for each test were selected to have the same opacity readings when clean.

The following procedure was employed in testing the filter: After the unit had been installed in the test duct and sealed against air leakage, the pressure switch was adjusted by the manufacturer's representative to operate the expander at a pressure difference of 0.8 in. W.G. The pressure drop across the compressed filter was then determined for the rated air flow rate and for airflows 20 percent lower and higher than the rated flow rate.

The initial arrestance value at the rated air flow rate, using the laboratory air as the aerosol, showed a value which was considered too low by the manufacturer's representative. An examination of the filter pack showed that the discoloration of the portion of the first and last layers, which covered the square holes was excessive. According to the manufacturer's representative, these end layers were cut from the ends of a roll of glass fiber and were considerably thinner than the nominal 0.5 in.

The end layers of a second filter pack were then installed in addition to the original ones. When the first filter pack was again installed in the test apparatus, it was found that the pressure drop at the rated air flow rate of 1000 cfm had increased from 0.448 in. W.G. to 0.665 in. W.G. By expanding the filter pack one step, the pressure drop decreased to 0.568 in. W.G. and when it was expanded a second step, it decreased to 0.480 in. W.G. The manufacturer's representative decided to use this step for the beginning of the test, pointing out

that the additional end layers had produced a too-tightly packed filter and would reduce the dust holding capacity.

The pressure drop of the modified filter was then determined for the same three air flow rates and two determinations of the arrestance were made at the rated air flow rate with atmospheric air. Thereafter, the filter was loaded with a mixture of 96 percent Cottrell precipitate and 4 percent cotton lint, by weight, in a concentration of one gram per 1000 cu ft of air. The Cottrell precipitate and the lint were dispersed separately into the air stream. The lint used for this purpose was No. 7 cotton linters previously ground in a Wiley Mill with a 4-millimeter screen. It was dispersed into the air stream through an aspirator operating at about 35 psi inlet air pressure. At intervals, the arrestance of the filter was determined using 100 percent Cottrell precipitate in laboratory air. Also, several more arrestance determinations with atmospheric dust were made.

The pressure drop was recorded as it increased with the dust load, and also the decrease of the pressure drop when the filter pack was expanded by one step.

The filter was loaded beyond its regular pressure drop after it had been fully expanded to determine the rate of rise of the pressure drop when overloaded.

4. Test Results

A summary of the test results is presented in Table I which shows the cumulative dust loads, the pressure drop, and the arrestance values determined with atmospheric dust and Cottrell precipitate at an air flow rate of 1000 cfm. The pressure drop immediately before and after each of the three expansions of the filter pack is also given. Figure 1 shows the values of this table in a graph.

Table I

Performance of Flanders Expansible Dust Filter, No. 15

Total Load grams	Pressure Drop in. W.G.	Arrestance %	Test Dust[d]
0	0.480	51.6[c]	A
10	0.482	82.7	C
238	0.657	95.6	C
415	0.812[a]/0.640[b]	95.8[c]	C
602	0.840[a]/0.680[b]	56.6	A
633	0.724	95.2[c]	C
727	0.815[a]/0.650[b]	62.2	A
892	0.810	93.0[c]	C
944	1.10	-	
965	1.23	62.2	A
996	-	95.2[c]	C

a Pressure drop before expansion
b Pressure drop after expansion
c Average of two tests
d Test Dust
  A Particulate matter in atmospheric air in the laboratory
  C Cottrell precipitate

The pressure drop of the clean filter as modified prior to the tests at different air flow rates was as follows:

Air Flow Rate, cfm	Pressure Drop, in. W.G.
800	0.360
1000	0.480
1200	0.608

Two values are given in Table I for the pressure drop at total loads of 415, 602, and 727 grams respectively. These two values correspond to the pressure drop of the filter immediately before and after it was expanded by one step.

The pressure drop of the clean filter increased from 0.480 in. W.G. to 0.812 in. W. G. as 415 grams of dust were introduced into the system. At that time it expanded and the pressure drop was reduced to 0.640 in. W.G. As the loading was continued, the next two expansions took place after 187 grams and 125 grams additional dust were introduced with similar effect on the pressure drop.

5. Discussion and Conclusions

Figure 1 shows that the total dirt holding capacity of the test specimen under these conditions of test was about 890 grams at a final pressure drop of 0.84 in. W.G. with the media fully expanded. It seems probable that the dirt holding capacity would have been appreciably higher if the first two expansion steps could have been used during the test. The average arrestance during the loading period, determined from the curves in Figure 1, was approximately 94% for Cottrell precipitate and 58% for the atmospheric dust in the vicinity of the laboratory.

The fact that the end layers of both filter packs submitted for test were considered faulty by the manufacturer, indicates that the production control was probably inadequate and that the results reported are not necessarily indicative of the performance of the commercial product.

At the end of the loading test, the filter medium was again compressed and the pressure switch of the expander was reset. After introducing a small amount of Cottrell precipitate, the expander functioned to expand the media. It was observed that a considerable amount of dust was carried through the filter as a result of the mechanical shock of the expander action and the movement of the media, appearing as a dust cloud at the outlet of the exhaust blower. This observation indicates that some of the dust load penetrated the entire media during the expanding process. The filter was not under observation for dust penetration at the time of expansion during the major part of the loading tests summarized in Table I. It seems probable that the same thing would have occurred to a greater or lesser degree at each expansion. An expansion mechanism that provided less mechanical shock when it functioned would probably alleviate this dust penetration of the media.

FLANDERS EXPANSIBLE DUST FILTER

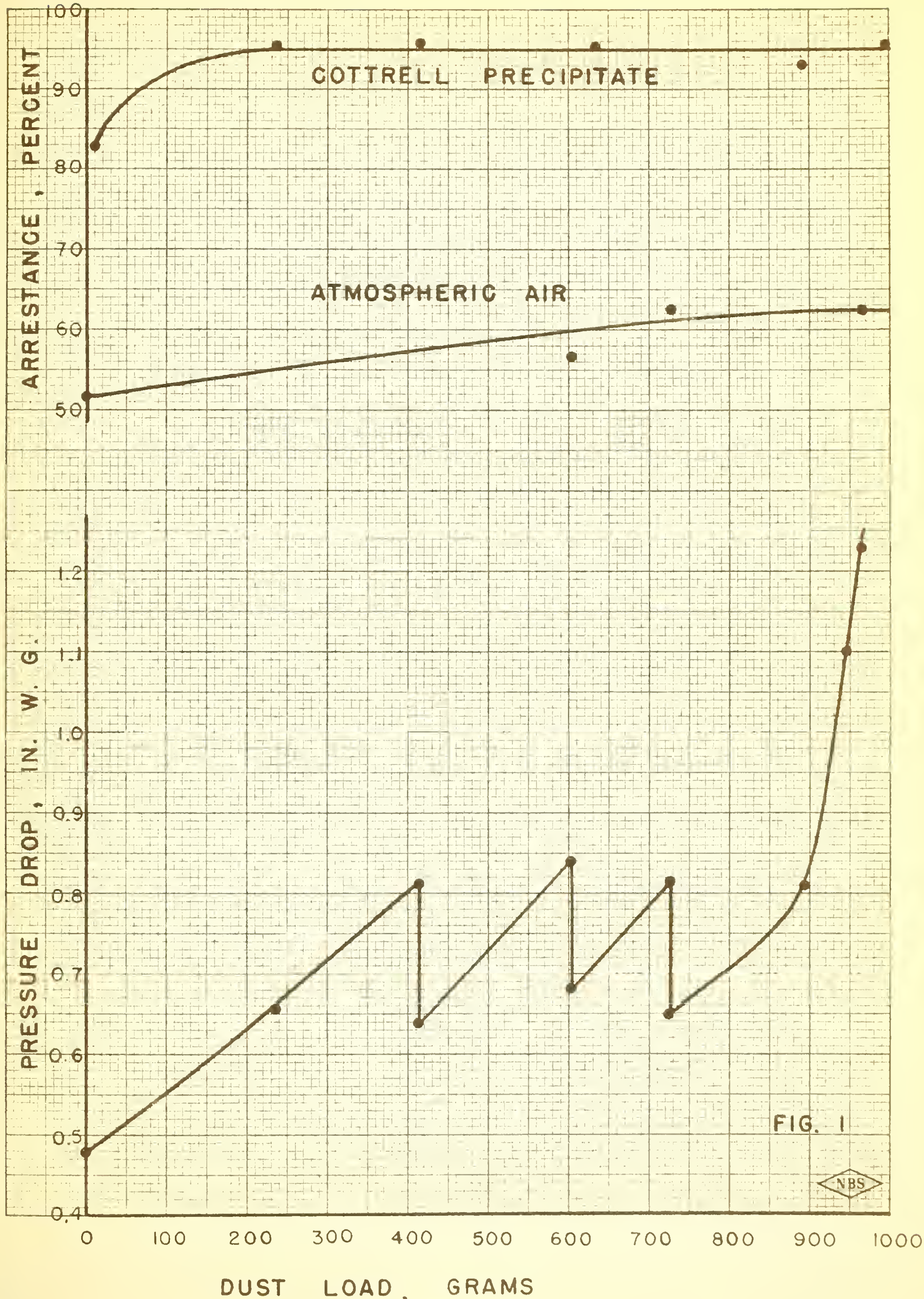

FIG. 1

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Sinclair Weeks, *Secretary*

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

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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. Nuclear Physics. Radioactivity. X-rays. Betatron. 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. Concreting Materials. 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.

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 Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering. Radio Meteorology.

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