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NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE TEST OF MODEL HP-2A

DRY TYPE REPLACEABLE FILTER

by

Charles M. Hunt

Report to

General Services Administration
Washington, D. C.



U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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1. Introduction

At the request of the Public Buildings Service of the General Services Administration performance characteristics of a Farr HP-2A filter were determined. The scope of the investigation included determination of the arrestance of the particulate matter in laboratory air and of Cottrell precipitate by the filter, and of pressure drop across the filter at the rated air flow of 1000 cfm as the dust load was increased from zero to a final pressure drop in excess of 0.5 inches W.G. The dust-holding capacity for a final pressure drop of 0.5 in. W.G. was also determined.

2. Description of Test Specimens

The HP-2A filter consisted of a permanent frame approximately 24 x 24 x 12 inches deep, in which is mounted a replaceable pleated filtering media formed in twelve vertical pleats or pockets about 11-1/2 inches deep which fit into and were supported by the frame. The working face dimensions of the filter proper were 22 x 22 inches giving a face area of about 3.4 ft². Due to the pockets the effective media filtering surface was 40 ft² or more. According to Farr Company Bulletin B-1300-4A, the rated capacity of this size filter is 1000 cfm.

The filtering media was about 0.1 in. thick and was backed on the downstream side by a light square-weave net fabric having a thread count of about twelve threads per inch. Seen under the microscope, the fibers

of the media appeared to be cotton. When they were mounted in water, patches of insoluble non-fibrous material could be seen, which may represent some kind of chemical treatment, or a binder or fire retarder. The upstream face of the filter was treated with a material which imparted a blue color. The media would burn when held in a flame but combustion ceased immediately upon removal.

3. Test Method and Procedure

The filters were tested at the rated capacity of 1000 cfm. The arrestance determinations were made with the NBS Dust Spot Method described in a paper by R. S. Dill entitled, "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, page 379, 1938). The filter under test was installed in the test apparatus and carefully sealed to prevent any by-pass of air, or inward flow of air into the test apparatus except through the measuring orifice. After establishing the correct air flow rate through the filter, samples of air were drawn from the center points of the test duct 2 feet upstream and 8 feet downstream of the test specimen. Each sample of air was passed through Whatman No. 41 filter paper. Arrestance determinations were made with the particulate matter in laboratory air as the aerosol and also with Cottrell precipitate injected into the air stream at an average concentration of about one gram per 1000 cu. ft. of air.

The relative amount of light passing through the sampling papers was measured on the same area of each paper before and after test, and the two sampling papers used for any one arrestance determination were selected to have the same light transmission when clean.

In determining arrestance, the areas of sampling paper upstream and downstream were selected so as to obtain dust spots of similar density. The arrestance was then calculated by the equation:

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

where A represents the percent arrestance, ΔU and ΔD represent the relative change in the amount of light passing through the upstream and downstream papers due to the dust spots, and S_U and S_D represent the areas of sampling paper upstream and downstream.

The filter was loaded with test dust consisting of 96 parts by weight of Cottrell precipitate and 4 parts of No. 7 cotton linters. The Cottrell precipitate was dispersed into the air stream at a rate of 1 gram per 1000 cu. ft. of air, and the cotton linters were dispersed separately after each 20 gram increment of Cottrell precipitate. Arrestance determinations were made initially and at selected intervals in the dust loading process.

Most of the data was obtained with a single filter, but a second filter of the same type was tested for initial pressure drop with atmospheric air.

4. Test Results

The amount of dust fed to the filter, the pressure drop across the filter, and arrestances for atmospheric dust and for Cottrell precipitate are summarized in Table 1. Most of the arrestance values in the table are averages of two or more determinations. The same data are plotted in figure 1 where the two upper curves represent arrestance as a function

of total dust fed, and the lower curve shows the pressure drop plotted against dust fed.

As noted in Table 1, the initial pressure drop across the filter at the rated capacity of 1000 cfm was 0.060 inches W.G. This value was duplicated by the second filter.

From the bottom curve in figure 1 the dust fed to the filter when a pressure drop of 0.5 inches was reached is seen to be 1430 grams. This corresponds to a nominal dust holding capacity of 1360 grams when corrected for 4.7% upstream fallout. This figure includes dust passing the filter as well as dust retained.

Discontinuities are present in the loading curve. The first one was obtained by raising the flow rate successively to 1500 cfm and 2000 cfm, lowering it to 500 cfm, and then returning it to 1000 cfm as noted in footnote c in Table 1. The subsequent discontinuities represent decreases in pressure drop observed when airflow through the filter was resumed after shutting down overnight or over a weekend. This behavior has also been observed in sac type filters and has been attributed to sagging of the filter when the flow is reduced resulting in dust fall-off. In the HP-2A filter, however, the frame appears to give good support to the filter. Nevertheless, irregularities in the pressure-drop curve were obtained. The form of this curve suggests that if loading were carried on continuously day and night a slightly lower dust holding capacity might be obtained as suggested by the dashed line. However, the dust-holding requirement for a type-C filter, according to General Services Administration Standard Air Conditioning Specification of December 1964, is 275 grams per 1000 cfm of specified capacity, and the capability of the filter exceeded this requirement substantially.

The initial arrestance for Cottrell precipitate was 78.7 percent, and an arrestance of 93.0 percent was obtained after about 1490 grams of dust, net, had reached the filter. The average arrestance was 87.3 percent, based on the area under the curve in figure 1 up to a dust load corresponding to a final pressure drop of 0.5 in. W.G.

A repeatable initial arrestance with atmospheric dust was not obtained, as noted in footnote d of Table 1. However, arrestance improved as air was drawn through the filter. One suspected source of difficulty is that small amounts of the fire-proofing or binding agent may have dusted out of the filter during the first few hours. This was suggested by spurious negative arrestances which were obtained initially with the filter, after the duct had been checked out for arrestance with no filter in place. Also, small but visible amounts of blue discoloration could be observed when the hand was passed lightly over the upstream surface of the second filter.

Arrestance of atmospheric dust became repeatable after loading with test dust was begun and reached a final value of 58.0 percent after 1490 grams (net) of dust had reached the filter. The average arrestance calculated from the middle curve of figure 1 was 43.3 percent when integrated up to the amount of dust fed when a pressure drop of 0.5 in. W.G. was reached.

In Table 2 the performance of the Farr HP-2A filter operating at its rated capacity of 1000 cfm is compared with the requirements for type-C filters according to General Services Administration "Standard Air Conditioning Specifications" of December 1964.

FOOTNOTES FOR TABLE 1

- a. At the conclusion of the measurements, 78 grams of dust were collected upstream from the filter. This corresponds to 4.7% of the total dust fed, or conversely only 95.3% of the dust reached the filter. If it is assumed that the percentage of fallout was constant throughout the dust feeding period, each value in this column may be multiplied by 0.953 to obtain a corrected estimate of the dust reaching the filter.
- b. The apparatus was shut down overnight and over weekends. These pressure drop readings were obtained when measurements were resumed.
- c. At this point the flow rate through the filter was measured at 1500, 2000, 500, and 1000 cfm. The pressure drop did not return to its original value. The flow rates and corresponding pressure drops were obtained in the following sequence,

	<u>cfm</u>	<u>In.</u> <u>W.G.</u>
1.	1000	0.115
2.	1500	.209
3.	2000	.334
4.	500	.031
5.	1000	.096

- d. No satisfactory initial arrestance with atmospheric dust was obtained. After a sequence of negative values, arrestances of 9.0, 18.0, and 41.8 percent were obtained. On the second filter an initial arrestance of 10.4% was obtained after air had been drawn through the filter for two to three hours.

Table 1

Performance of Farr HP-2A Filter at 1000 cfm

Dust Fed ^a (grams)	Pressure Drop Across Filter (in. W.G.)	Arrestance	
		Atmospheric Dust %	Cottrell Ppt. %
First Filter			
0	0.060	d	78.7
139	.088		
171	.099	34.3	81.2
289	.122		
	.115 b		
	.096 c		
393	.120		
518	.149		
622	.176		
	.171 b		
726	.201	48.6	87.4
810	.230		
893	.265		
	.264 b		
976	.301	46.8	92.1
1018	.328		
	.320 b		
1143	.397	50.0	92.6
	.296 b		
1268	.389		
1393	.494	51.4	93.7
	.470 b		
1518	.582		
1560	.612	58.0	93.0
	.576 b		
1643	.722		
Second Filter			
0	0.060	10.4	—

Footnotes on preceding page.

Table 2

Performance of Farr HP-2A filter compared with GSA requirements for type-C filters.

	<u>Farr HP-2A</u>	<u>Requirement Type-C filter</u>
Nominal dust holding capacity when 0.5 in. W.G. is reached, grams per 1000 cfm of capacity.	1360	275
Average arrestance for Cottrell ppt., percent.	87.3	80
Average arrestance for atmospheric dust, percent	44.5	not specified

FARR HP-2A FILTER 1000 CFM

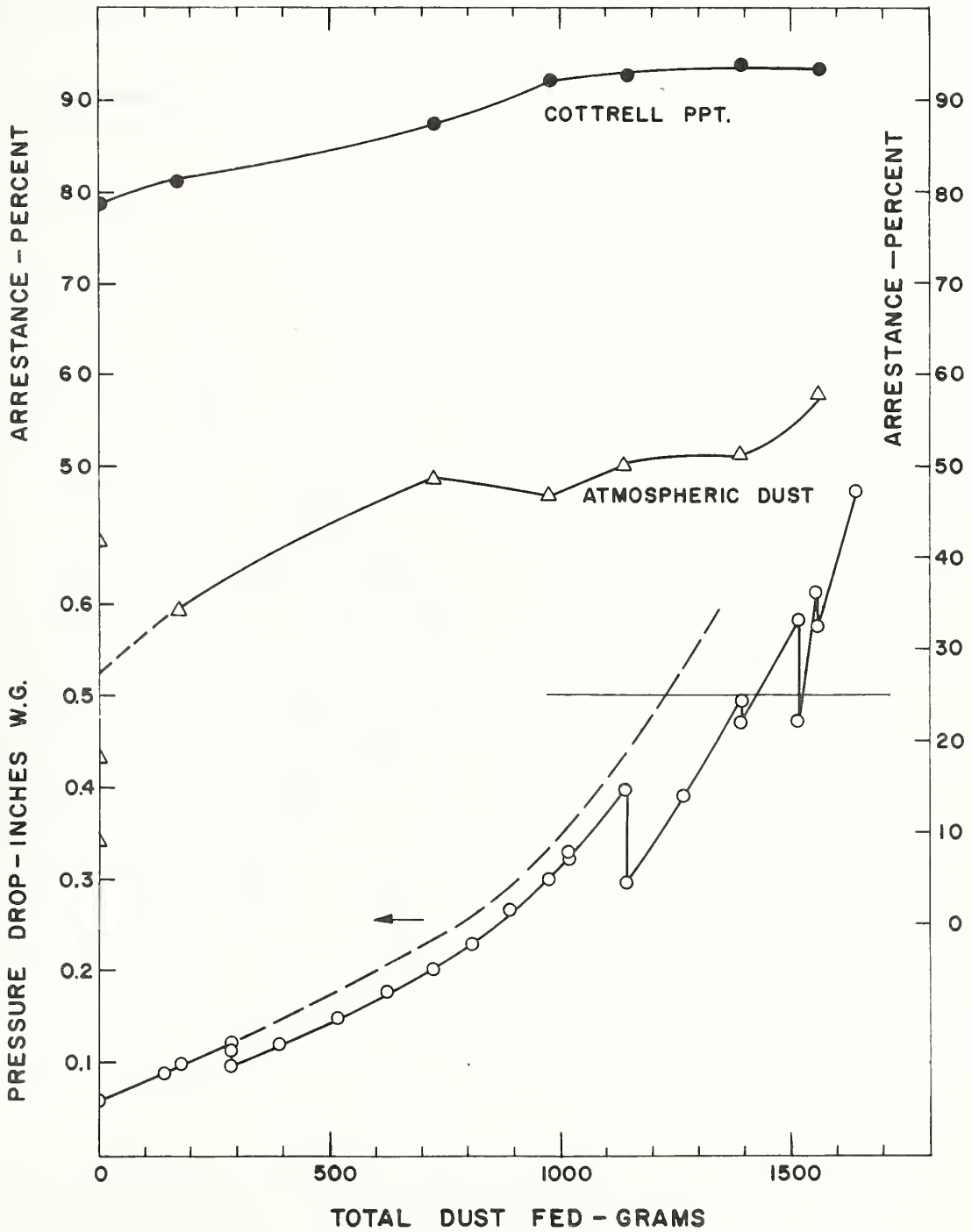


FIG. 1

