NATIONAL BUREAU OF STANDARDS REPORT

6154

PERFORMANCE TESTS OF
FOUR CLEANABLE IMPINGEMENT AIR FILTERS
TYPE 902, 912, 9102 and 9802

MANUFACTURED BY
RESEARCH PRODUCTS CORPORATION
MADISON, WISCONSIN

by

Carl W. Coblentz
and
Paul R. Achenbach

Report to
Bureau of Yards and Docks
Office of the Chief of Engineers
Headquarters, U. S. Air Force
Washington, D. C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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Air Conditioning, Heating, and Refrigeration Section
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1. Introduction

The performance characteristics of a group of cleanable viscous impingement air filters were measured to provide information for evaluating the relative economy of cleanable versus throw-away types of filters. This investigation was requested by the Defense Department through the Tri-Service program of research and development at the National Bureau of Standards to obtain the required data for the preparation of new air filter specifications.

The test results presented herein were obtained on four new filters and include determination of the arrestance and pressure drop as a function of specific dirt load and information on cleanability for face velocities of 360 and 540 ft/min.

2. Description of Test Specimens

The four test specimens were of the cleanable viscous impingement type and were manufactured and supplied by the Research Products Corporation of Madison, Wisconsin. They were identified as "Industrial Filter" models #902 and #912 and the "E Z Kleen" models #9102 and #9802. All specimens had outside dimensions of 19 1/2" x 19 1/2"; the #902 and #9102 were 1 7/8 in. thick and #912 and #9802 were 7/8 inch thick; the net filter area of all specimens was 2.25 sq ft. The nominal thicknesses of 2 in. for filters #902 and #9102 and 1 in. for filters #912 and #9802 will be used for discussion purposes in the remainder of this report.

The frames were made of aluminum sheet formed into a U-shaped channel. The aluminum used in the frames of the Industrial type filters was approximately 0.05 in. thick, whereas that for the E Z Kleen filters was approximately 0.020 in. thick. The filter media were also made of aluminum sheet which was slit and expanded into a light screen. Each filter had coarse and fine screens in different numbers. The Industrial types used 0.010 and 0.006 in. thick sheets and the E Z Kleen types used 0.006 and 0.003 in. thick sheets; the latter types also had a reinforcing grid of 0.100 in. aluminum wire made in 4 1/2 in. squares.

Adjacent layers of each media were placed so the direction of expanding the sheets was at right angles in order to deflect the air flow direction and promote impingement of dust. From 10 to 21 layers of expanded aluminum sheet were counted in each filter.

The adhesive was supplied by the manufacturer, and was identified by the trade mark #412 Super Filter Coat. It was claimed that this adhesive would absorb odors, but this characteristic was not investigated during this test.

3. Test Method and Procedure

The performance of the filters was determined at 360 ft/min and 540 ft/min face velocity, i.e., at an air flow rate of 810 cfm and 1215 cfm, respectively. The clean filters were immersed in the adhesive and left to dry in the laboratory at least 16 hours before being weighed and installed in the test apparatus. The initial pressure drop at each air velocity was measured and then the initial arrestance at the air velocity desired for that test was determined with the NBS "Dust Spot Method" as described in the paper, "A Test Method for Air Filters," by R. S. Dill (ASHVE Transactions, Vol. 44, p. 379, 1938).

The aerosol used for the arrestance determinations was Cottrell precipitate which had been sifted through a 100-mesh wire screen. In order to simulate actual operating conditions when loading the filters, four percent by weight of #7 cotton linters, previously ground in a Wiley mill with a four-millimeter screen, was fed simultaneously with the Cottrell precipitate. The pressure drop of the filters was recorded after each increment of 20 g of dust introduced into the apparatus. Whereas the arrestance measurements were made with 100 percent Cottrell precipitate, cotton linters were added to retain a ratio of four parts by weight to every 96 parts of Cottrell precipitate, including that amount used for the arrestance measurements. Arrestance determinations were made at the beginning and at the end of the loading period for each filter and at several intermediate load conditions. The filters were loaded with a dust concentration of approximately 1 g dust in 1000 cu ft of air until the pressure drop reached 0.5 in. W.G. in 360 ft/min face velocity tests and 0.8 in. W.G. in the tests with 540 ft/min face velocity.

After the filters had been loaded to capacity, they were cleaned with water and allowed to dry; then, oiled again as previously described, weighed and installed in the test apparatus for determining any change in pressure drop and in some cases for a new performance test.

4. Test Results

The data on pressure drops and arrestance observed during the loading tests of the four filters are summarized in Tables 1 to 8, inclusive.

Table 1

Performance of Industrial Filter #902(2 in. thick) at 360 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.060	--
3	0.062	53
7	0.062	53
151	0.152	61
215	0.210	62
266	0.310	65
325	0.495	64
331	0.515	--

Table 2

Performance of Industrial Filter #902(2 in. thick) at 540 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.146	--
3	0.149	59
94	0.241	57
139	0.305	58
193	0.439	64
247	0.605	66
283	0.775	70
293	0.815	--

Table 3

Performance of Industrial Filter #912(1 in. thick) at 360 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.040	--
3	0.041	47
37	0.051	46
63	0.065	48
96	0.087	50
181	0.165	45
215	0.215	47
274	0.340	52
300	0.424	49
317	0.509	52

Table 4
Performance of Industrial Filter #912(1 in. thick) at 540 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.087	--
7	0.091	42
52	0.112	40
133	0.175	43
178	0.227	48
268	0.396	51
318	0.536	54
359	0.656	60
395	0.900	63

Table 5

Performance of E Z Kleen Filter #9102(2 in. thick) at 360 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.096	--
3	0.100	53
12	0.105	53
54	0.133	57
105	0.181	54
156	0.255	58
207	0.375	64
249	0.530	64
252	0.542	65

Table 6

Performance of E Z Kleen Filter #9102(2 in. thick) at 540 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.190	--
3	0.193	56
7	0.195	56
40	0.216	55
103	0.287	61
112	0.305	60
157	0.368	62
202	0.451	61
247	0.605	63
294	0.805	65
298	0.808	66

Table 7

Performance of E Z Kleen Filter #9802(1 in. thick) at 360 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.105	--
3	0.106	52
7	0.108	51
54	0.173	54
105	0.291	59
159	0.555	62

Table 8

Performance of E Z Kleen Filter #9802(1 in. thick) at 540 ft/min Face Velocity

Load g/sq ft	Pressure Drop in. W.G.	Arrestance %
0	0.235	--
3	0.235	52
7	0.236	52
58	0.318	50
117	0.490	58
169	0.820	62

The preceding tables show the arrestance values and the pressure drop as a function of the dirt load per square foot of net filter area at face velocities of 360 ft/min and 540 ft/min. Fig. 1 to 4 present these same values graphically using smooth curves to approximately fit the individual points of observation.

Fig. 1 to 4 show that the arrestance of all four models increased with increasing dust load, but the rate of increase in arrestance varied considerably. For example, model 912 showed less than 3% change in arrestance between the clean and loaded filter at a face velocity of 360 ft/min, but the same filter had about 20% greater arrestance when loaded than when clean at a face velocity of 540 ft/min. This filter revealed only a small difference in pressure drop for the two face velocities throughout most of the loading period.

The dust loads indicated by these graphs at 0.5 in. W.G. pressure drop for 360 ft/min face velocity and at 0.8 in. W.G. for 540 ft/min face velocity have been tabulated in table 9 as "Dust Holding Capacity". Also shown in this table are the mean arrestance values for each filter and each face velocity during the period in which the capacity dust load was being deposited.

Table 9 shows that the average arrestance during the loading period was nearly the same for each filter at face velocities of 360 ft/min and 540 ft/min. However, the arrestance values were somewhat higher for the 2-in. thick media than for the 1-in. thick media. This difference was more pronounced in the Industrial type filters than in the E Z Kleen types. There was no great variation in dust-holding capacity between the two face velocities, but the dust-holding capacity of the 1-in. thick E Z Kleen was significantly lower than the rest.

Table 9

Dust Holding Capacity and Mean Arrestance
(Determined from Figs. 1 to 4)

	Industrial Type				E Z Kleen Type			
Filter Number	902		912		9102		9802	
Thickness of Filter, inch.	2		1		2		1	
Face Velocity, ft/min	360	540	360	540	360	540	360	540
Final Pressure Drop, in. W.G.	0.5	0.8	0.5	0.8	0.5	0.8	0.5	0.8
Dust Holding Capacity, grams/ sq ft.	326	290	316	386	240	294	152	168
Mean Arrestance, percent	60	62	48	48	58	61	56	55

The weights of the oiled filters and also the pressure drop values for both face velocities are shown in table 10 for the filters when new and after each loading and cleaning cycle.

Table 10

Cleanability of Filters

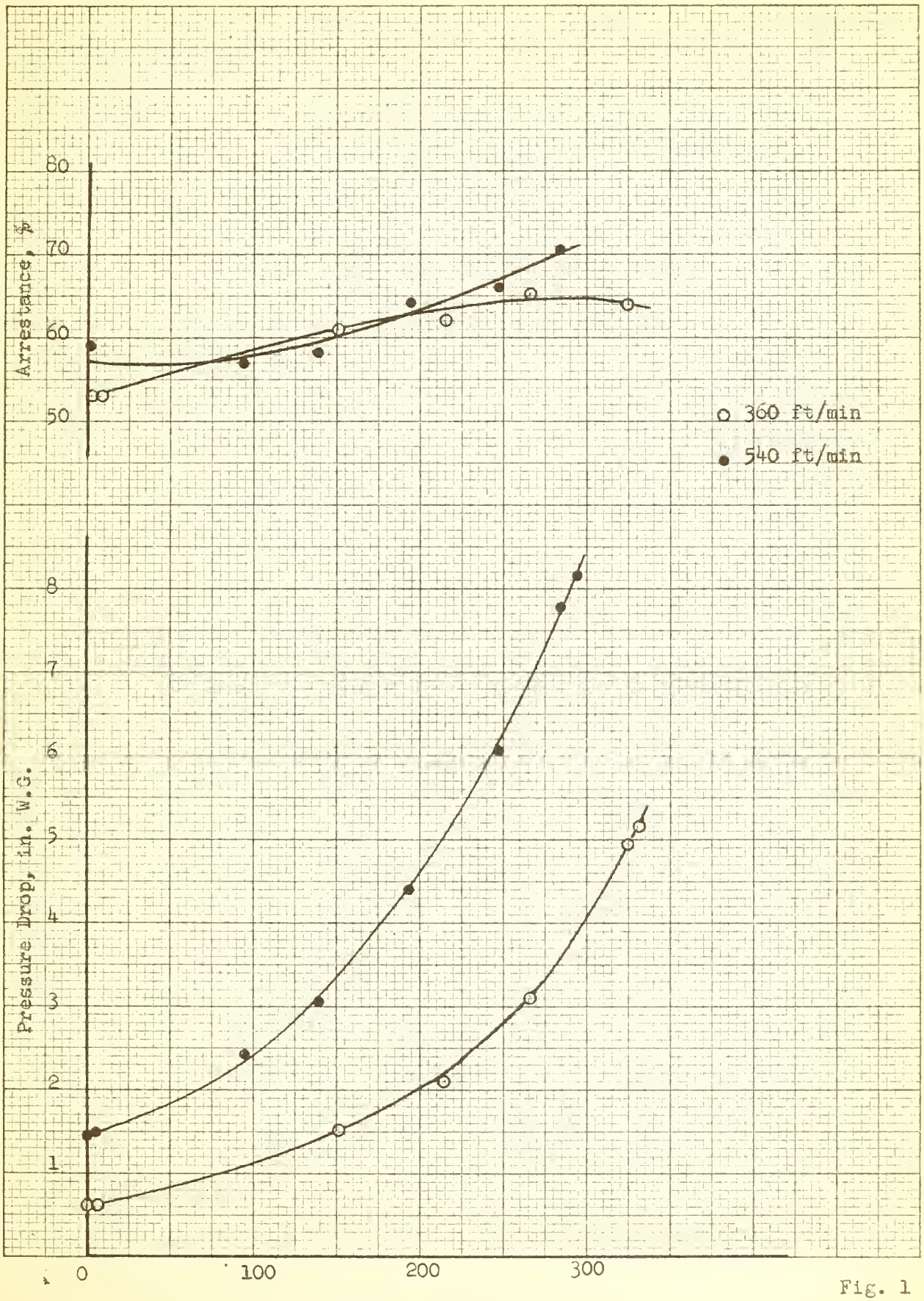
Type and Condition of Filter	Weight of Filter grams	Pressure Drop, in. W.G. 360 ft/min	540 ft/min
#902			
New	1690	0.065	0.140
After 1 loading and cleaning	1902	0.068	0.146
After 2 loadings and cleanings	1887	0.075	0.162
" 3 " " "	1908	0.083	0.183
" 4 " " " *	1655	0.060	0.130
* Adhesive mixed with water in ratio of 1:3 instead of previous ratio of 1:1.			
#912			
New	1105	0.040	0.085
After 1 loading and cleaning	1117	0.040	0.087
After 2 loadings and cleanings	1162	0.043	0.099

Table 10(cont.)

Type and Condition of Filter	Weight of Filter grams	Pressure Drop, in. W.G. 360 ft/min	540 ft/min
#9102			
New	982	0.085	0.190
After 1 loading and cleaning	---	0.096	0.210
After 2 loadings and cleanings	1065	0.105	0.220
#9802			
New	677	0.105	0.235
After 1 loading and cleaning	695	0.106	0.235
After 2 loadings and cleanings	692	0.105	0.238

It will be noticed that the weight and also the pressure drop of filter type 902 increased considerably during the first three successive loadings. However, when a fourth test was made in which the adhesive was diluted with water in a ratio 1 to 3 instead of 1 to 1 as previously done, the weight and pressure drop decreased to values below those observed for the new filter. Although the initial pressure drop with the thinner adhesive was lower, the dust holding capacity at its final pressure drop was the same and no change in the arrestance value was observed.

Industrial Filter #902 (2" thick)



Dust Load, grams per sq ft

Fig. 1

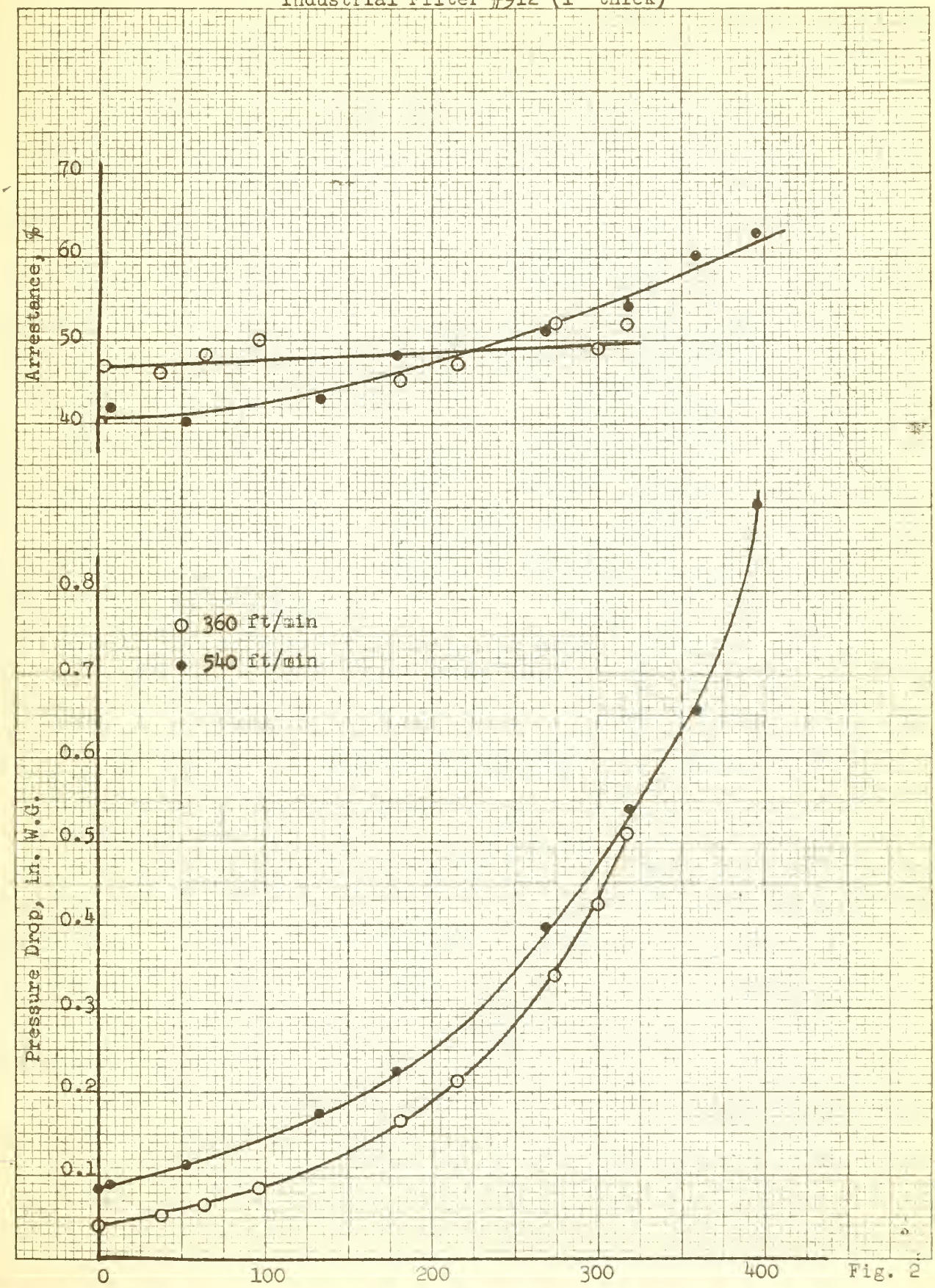

Industrial Filter #912 (1" thick)
Arrestance, %
70
60
50
40
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
Pressure Drop, in. W.G.
360 ft/min
540 ft/min
0
100
200
300
400
Dust Load, grams per sq ft

Fig. 2

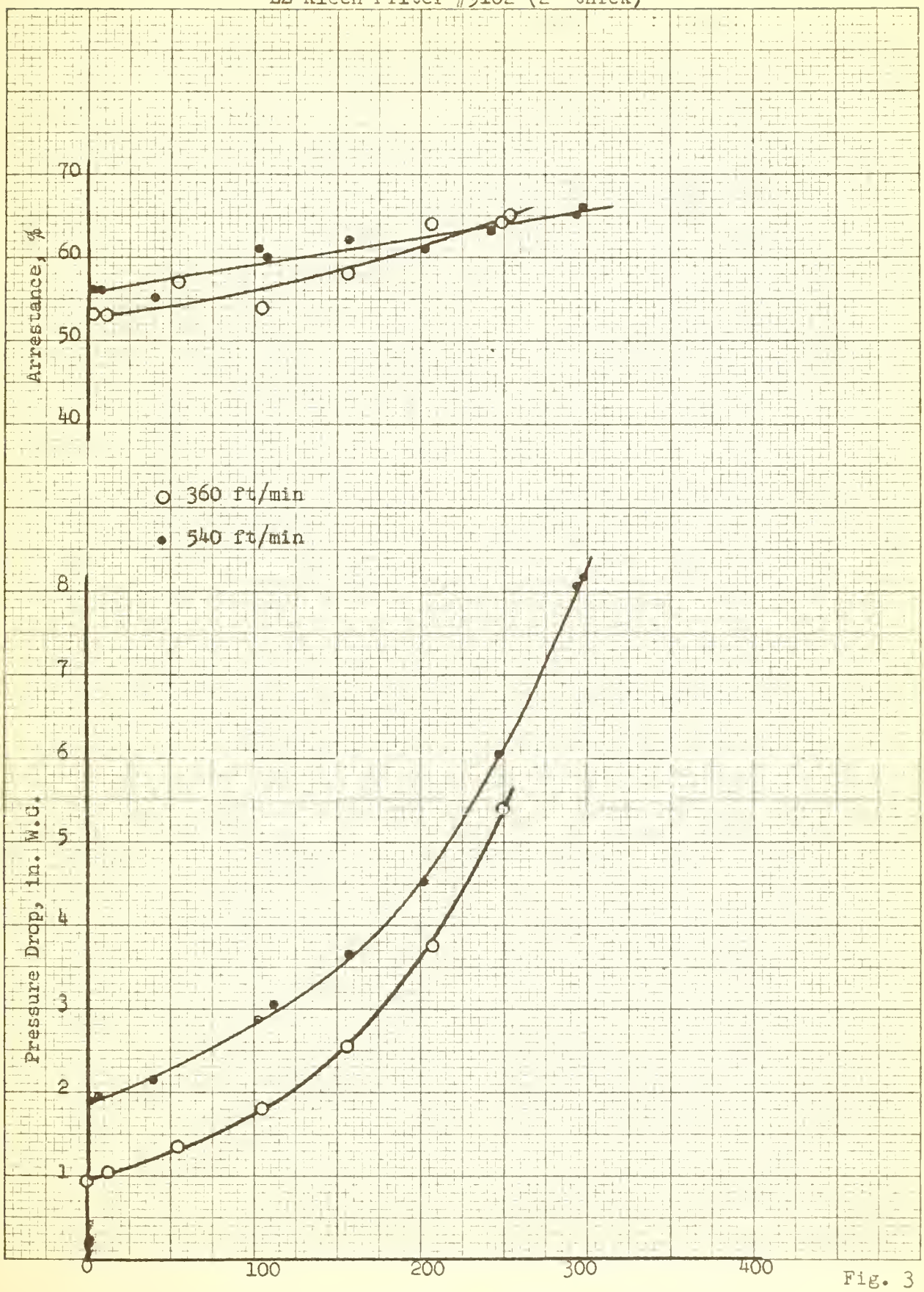

EZ Kleen Filter #9102 (2" thick)
Arrestance, %
70
60
50
40
360 ft/min
540 ft/min
Pressure Drop, in. W.G.
8
7
6
5
4
3
2
1
0
100
200
300
400
Dust Load, grams per sq ft

Fig. 3

EZ Kleen Filter #9602 (1" thick)

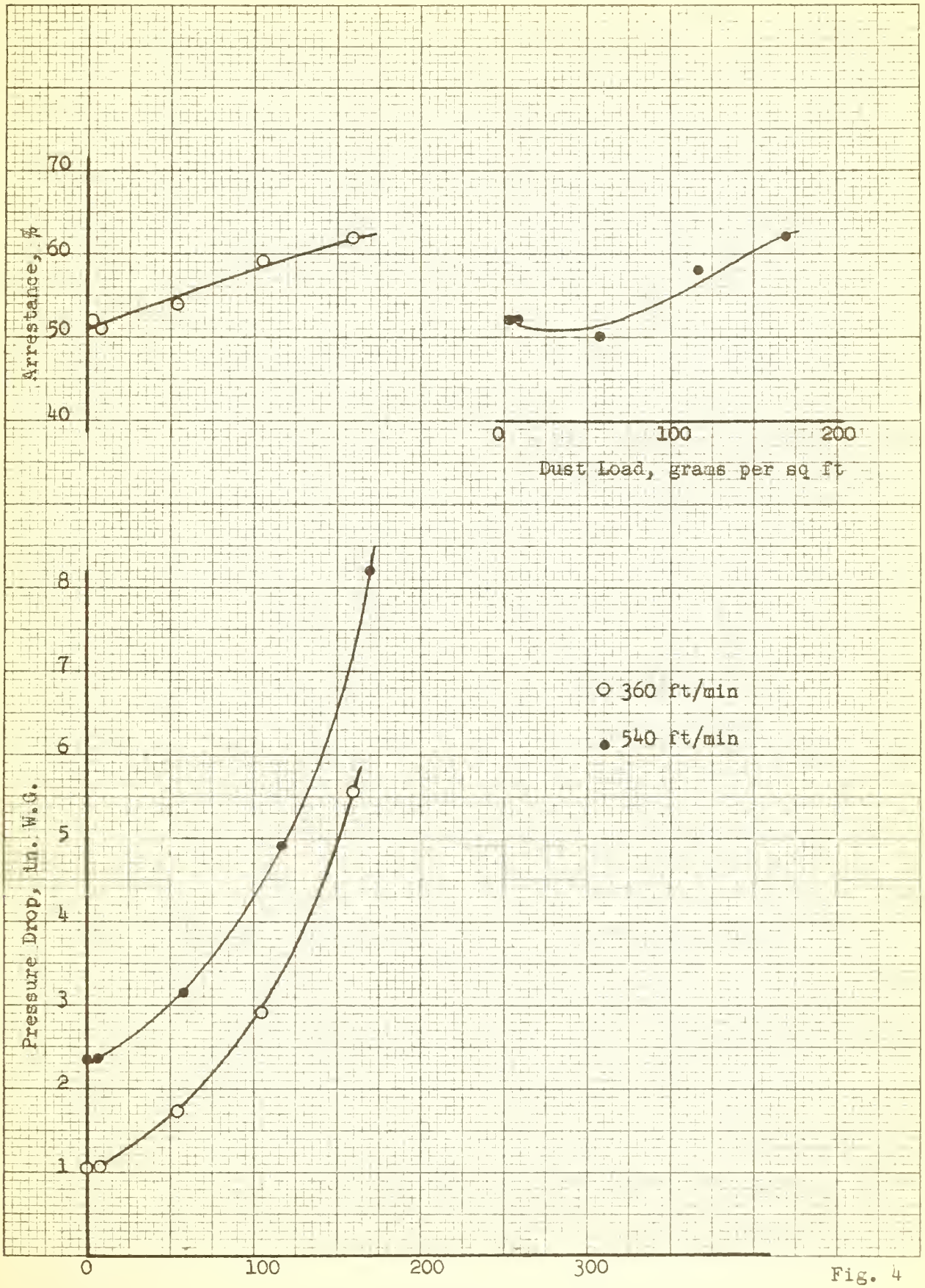


Fig. 4

U. S. DEPARTMENT OF COMMERCE
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NATIONAL BUREAU OF STANDARDS
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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. 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.

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

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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

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


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