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NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE TESTS OF CLEANABLE
IMPINGEMENT TYPE AIR FILTERS
TYPE VS AND TYPE VR
(VORTOX)

by

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NBS

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NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT | **NBS REPORT**

1003-20-4715 March 4, 1953 2322

PERFORMANCE TESTS OF CLEANABLE
IMPINGEMENT TYPE AIR FILTERS
TYPE VS AND TYPE VR

manufactured by
Vortox Company
Claremont, California.

by

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Heating and Air Conditioning Section
Building Technology Division

to

Bureau of Ships, Code 327
Department of the Navy

Reference: NPO - 15479 Index No. NSM 130-001

NBS

PERFORMANCE TESTS OF CLEANABLE IMPINGEMENT TYPE AIR FILTERS TYPE VS AND TYPE VR

I. INTRODUCTION

At the request of the Bureau of Ships, Code 327, Navy Department (NPO-15479, Index No. NSM 130-001) qualification tests were made to determine the performance of cleanable viscid-impingement type air filters in accordance with Section 4.5 of Military Specification MIL-F-16552 (Ships) dated 1 October 1951 as modified by Amendment 1 dated 15 April 1952.

The tests were performed on specimen filters submitted by the manufacturer at the request of the Bureau of Ships, and included determinations of the dust-arresting efficiency, pressure drop, specific dirt load and cleanability of the specimens at three face air velocities, namely 300, 600 and 900 feet per minute.

II. DESCRIPTION OF THE FILTER SPECIMENS

The two filters submitted were manufactured by the Vortox Company of Claremont, California, and were of the cleanable viscid type, 20x20x2 inches in nominal size. They were identified by their nameplates as Type VS and Type VR air filters.

The media of the filters consisted of multitudinous helical coils, about 5/16 inch in diameter formed from 0.011 inch iron or steel wire flashed with copper, apparently poured with random orientation into the space between the faces and the edges of the air filter frame.

The Type VS filter was composed of the following elements, starting at the upstream face: two layers of expanded metal 1/4x1/2 mesh; helical wire media; one layer of flat screen 14x18 mesh; one layer of expanded metal 1/4x1/2 mesh. The filter had actual outside dimensions of 19-9/16x19-9/16x1-7/8 inches, leaving a free opening 18x18-1/16 inches (2.26 ft^2 net face area) and weighed 11.0 lb. when clean and oiled.

The Type VR filter was similar in construction to the Type VS except that another layer of expanded metal 1/4x1/2 mesh was used in lieu of the 14x18 mesh flat screen. The filter had actual outside dimensions of 19-1/2x19-1/2x2-1/8 inches, leaving a free opening 17-7/8x17-15/16 inches (2.23 ft^2 net face area) and weighed 12.7 lb. when clean and oiled.

The manufacturer submitted an adhesive designated as "9974" for oiling both filters. This was done in preparation for the test by immersing the filters in the liquid and letting the excess oil drain off with the filters standing on edge for a minimum of 16 hours prior to the test.

III. TEST METHOD AND PROCEDURE

The dust-arresting efficiency of the filter was determined by the NBS "Dust Spot Method" using as a test dust Cottrell precipitate at a concentration of one gram per thousand cubic feet of air. 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).

Dirt-holding capacity was determined by supplying to the filter air in which were dispersed cotton lint and Cottrell precipitate in the approximate proportions of 4% and 96% by weight, respectively. The average rate of feed of the contaminants was not more than 25 grams per hour per square foot of net filter face area at each face velocity. The lint used for this purpose was No. 7 cotton linters ground in a Wiley mill with 4 mm screen.

The efficiency and dirt-loading tests were made at three different air velocities, namely, 300, 600 and 900 fpm.

In the tests at each velocity, the following uniform procedure was employed. The clean filter, after oiling and draining as described above, was installed in the test duct and its initial pressure drop was measured at 300, 600 and 900 fpm air velocity. The initial efficiency of the filter at the test velocity was then determined, following which the process of loading the filter with a mixture of 4 percent lint and 96 percent Cottrell precipitate by weight was started. At intervals the increasing pressure drop of the filter was recorded. At suitable periods as loading progressed, the efficiency of the filter was determined using 100 percent Cottrell precipitate. In addition, the efficiency of the filter was determined at the end of a day of loading, and at the start of the next day, to ascertain whether the rate of dirt loading was overtaxing the wetting rate of the filter adhesive. The dirt loading was continued, in general, until the rate of pressure drop rise increased to approximately 0.004 inch W.G. per gram of dirt mixture fed per square foot of filter face area.

The filter was then removed from the test duct and cleaned by means of a stream of cold water from a high-pressure hose nozzle, directed at and into the filter media. After drying, the filter was re-oiled for subsequent tests or for measurement of its initial pressure drop after the final cleaning.

IV. TEST RESULTS

The pressure drops of the clean oiled filters, in inch W.G., at 300, 600 and 900 fpm face air velocity, were measured at the start of each of the tests, and after the 900 fpm test, as shown in Table 1.

TABLE 1

Face Velocity, fpm	300	600	900
Type VS			
At start of 300 fpm test	0.040	.144	.316
At start of 600 fpm test	.041	.160	.372
At start of 900 fpm test	.048	.198	.450
After 900 fpm test	.073	.258	.555
Increase in P.D. after 3 cleanings, percent	83	79	76
Type VR			
At start of 300 fpm test	0.064	.207	.422
At start of 600 fpm test	.064	.217	.443
At start of 900 fpm test	.064	.215	.437
After 900 fpm test	.067	.225	.456
Increase in P.D. after 3 cleanings, percent	5	9	8

A summary of the test data obtained in dirt-loading tests conducted at 300, 600 and 900 fpm face velocity is given in Table 2, for each of the filters.

TABLE 2

Filter	Face Velocity fpm	Dirt Load* grams/sq ft	Pressure Drop inch WG	Efficiency percent
VS	300	0	.040	-
		2	.040	43
		5	.041	44
		7	.041	45
		34	.052	47
		63	.067	-
		102	.087	51(P)
		104	.086	50(A)
		135	.107	56
		190	.161	56
		221	.200	59
		237	.225	61(P)
		240	.217	61(A)
		252	.250	64
		294	.352	68
		326	.512	73

*Average mixture: 4.0% lint, 96% Cottrell precipitate by weight.
Average rate of dirt loading: 19.7 grams per square foot per hour.

TABLE 2 - continued

Filter	Face Velocity fpm	Dirt Load* grams/sq ft	Pressure Drop inch WG	Efficiency percent
VS	600	0	.160	-
		6	.162	55
		12	.170	58
		28	.199	59
		64	.252	61
		119	.347	67
		137	.393	65(P)
		143	.390	61(A)
		150	.420	63
		177	.503	60
		223	.672	71
		250	.810	75

*Average mixture: 3.9% lint, 96.1% Cottrell precipitate by weight.
Average rate of dirt loading: 23.9 grams per square foot per hour.

Filter	Face Velocity fpm	Dirt Load* grams/sq ft	Pressure Drop inch WG	Efficiency percent
VS	900	0	.450	-
		9	.468	63
		18	.475	63
		46	.588	68
		73	.713	74(P)
		83	.710	74(A)
		110	.840	75
		138	.995	75
		147	1.060	80
		157	1.143	79

*Average mixture: 4.0% lint, 96% Cottrell precipitate by weight.
Average rate of dirt loading: 20.1 grams per square foot per hour.

Filter	Face Velocity fpm	Dirt Load* grams/sq ft	Pressure Drop inch WG	Efficiency percent
VR	300	0	.064	-
		3	.064	45
		6	.064	48
		8	.064	46
		26	.073	51
		73	.101	53
		101	.118	57(P)
		104	.122	57(A)
		132	.150	58
		166	.205	62
		169	.206	62
		189	.251	62
		228	.354	64
		259	.507	74

*Average mixture: 4.0% lint, 96% Cottrell precipitate by weight.
Average rate of dirt loading: 17.6 grams per square foot per hour.

TABLE 2 - continued

Filter	Face Velocity fpm	Dirt Load* grams/sq ft	Pressure Drop inch WG	Efficiency percent
VR	600	0	.217	-
		6	.220	52
		12	.225	55
		48	.285	61
		85	.350	64
		110	.396	64(P)
		116	.425	63(A)
		144	.510	69
		176	.633	73
		214	.811	73

*Average mixture: 3.9% lint, 96.1 Cottrell precipitate by weight.
Average rate of dirt loading: 20.6 grams per square foot per hour.

Filter	Face Velocity fpm	Dirt Load* grams/sq ft	Pressure Drop inch WG	Efficiency percent
VR	900	0	.437	-
		9	.450	58
		18	.458	65
		28	.500	69
		74	.655	70
		121	.835	72
		130	.880	73(P)
		140	.925	74(A)
		159	1.032	75

*Average mixture: 4.0% lint, 96% Cottrell precipitate by weight.
Average rate of dirt loading: 21.2 grams per square foot per hour.

Note: Efficiencies marked (P) or (A) were determinations made at the end of a day of loading, and at the start of the next day of loading, respectively.

V. SUMMARY OF RESULTS

A. Performance

The test data are plotted in Figure 1 and Figure 2, which show the variation of the pressure drop and of the efficiency of the filters as they were subjected to increasing specific dirt loading at face velocities of 300, 600 and 900 feet per minute.

Table 3 presents values of the pressure drop (P.D.), in inches of water, and of the approximate efficiency (Eff.), in percent, as taken from the curves of Figure 1 and Figure 2, at various specific dirt loadings.

TABLE 3

Spec. Dirt Ldg. grams/sq ft	0 (Initial)		100		200		300	
Face Vel., fpm	P.D.	Eff.	P.D.	Eff.	P.D.	Eff.	P.D.	Eff.
			VS					
300	0.04	43	.08	51	.17	57	.38	69
600	.16	55	.31	65	.58	65	-	-
900	.45	63	.79	74	-	-	-	-
			VR					
300	0.06	45	.12	57	.28	62	-	-
600	.22	52	.37	64	.74	74	-	-
900	.44	58	.75	71	-	-	-	-

B. Cleanability

The pressure drops of the clean oiled filters at 300, 600 and 900 fpm face velocity recorded in Table 1 under Test Results indicate that, after the Type VS filter had been subjected to three loadings with the dust-lint mixture and three cleanings and re-oilings, its average pressure drop showed an average increase of about 79 percent. This increase in pressure drop indicates that the Type VS filter was not satisfactorily cleanable by the method employed. The Type VR filter had an average increase in pressure drop of about 7 percent over its original measurement. This change is within the uncertainty with which the cleaning operation, which is necessarily involved in the process of ascertaining cleanability, could be performed. It is believed the Type VR filter can be considered as satisfactorily cleanable.

It should be noted that the initial resistance (0.450 inch W.G.) of the Type VS filter at the start of the 900 fpm velocity test was considerably higher than the initial resistance (0.316) of the same filter before the 300 fpm velocity test. The increase was due to dirt in the filter which could not be removed by the cleaning operation; its effect was to cause the filter to start the 900 fpm loading test at a relatively high resistance, and therefore to reduce the dirt-holding capacity reckoned for any selected final resistance.

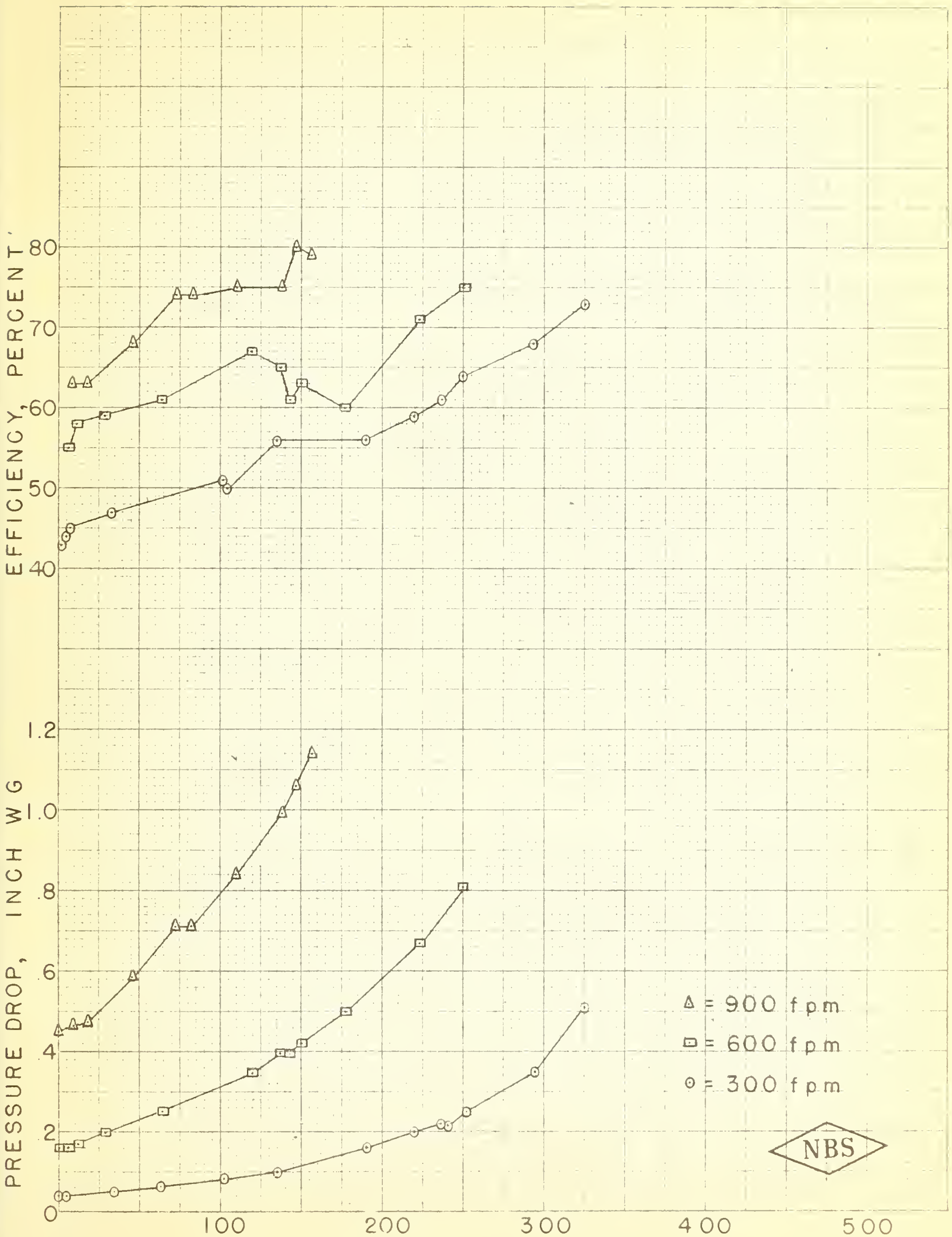
The difference in cleanability of the two filters appeared to be due chiefly to the 14x18 mesh flat screen just downstream of the filtering media in the Type VS filter, which made it difficult to flush water into, or dirt out of, the media on that side.

No visible evidence of shifting or compaction of the helical coil filtering media was observed in the course of these tests.

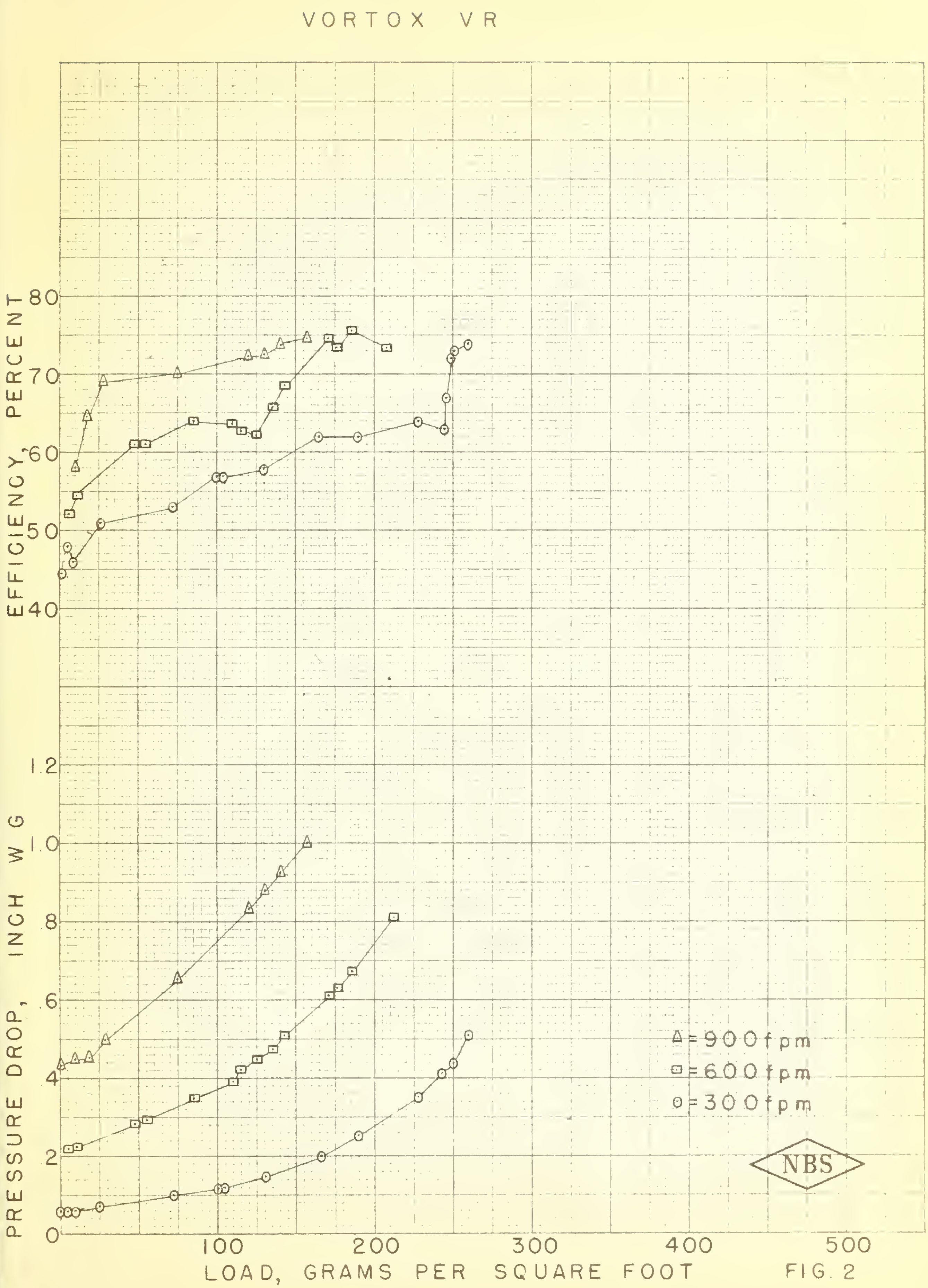
C. General

The fact that efficiencies determined at the end of a day of loading of the filters (those marked (P) in Table 2) were approximately the same as those made at the start of the next day of loading (those marked (A)) indicates that the dirt loading rates to which the filters were subjected did not overtax the wetting-rate of the filter adhesive and cause the filter surfaces to become "dry".

VORTOX VS



LOAD, GRAMS PER SQARE FOOT FIG. I


VORTOX VR
EFFICIENCY, PERCENT
80
70
60
50
40
PRESSURE DROP, INCH W G
1.2
1.0
.8
.6
.4
.2
0
100
200
300
400
500
LOAD, GRAMS PER SQUARE FOOT
Δ = 900 fpm
□ = 600 fpm
⊙ = 300 fpm
NBS
FIG. 2

THE NATIONAL BUREAU OF STANDARDS

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The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

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