NATIONAL BUREAU OF STANDARDS REPORT

3811 (Test Folder G 16786)

PERFORMANCE TESTS OF A CLEANABLE
IMPINGEMENT TYPE AIR FILTER
"E Z KLEEN" RP 9102

by
Henry E. Robinson
Thomas W. Watson

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

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

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

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section is engaged in specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside of the back cover of this report.

Electricity. Resistance and Reactance Measurements. Electrical Instruments. Magnetic Measurements. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Measurements. Thermodynamics. Cryogenic Physics. Engines and Lubrication. Engine Fuels. Cryogenic Engineering.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Neutron Measurements. Infrared Spectroscopy. Nuclear Physics. Radioactivity. X-Ray. Betatron. Nucleonic Instrumentation. Radiological Equipment. Atomic Energy Commission Radiation Instruments Branch.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Control.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion.

Mineral Products. Porcelain and Pottery. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering.

Electronics. Engineering Electronics. Electron Tubes. Electronic Computers. Electronic Instrumentation. Process Technology.

Radio Propagation. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Frequency Utilization Research. Tropospheric Propagation Research. High Frequency Standards. Microwave Standards.

●Office of Basic Instrumentation

●Office of Weights and Measures.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT **NBS REPORT**

1000-30-4830 December 7, 1954 3811

PERFORMANCE TESTS OF A CLEANABLE
IMPINGEMENT TYPE AIR FILTER
"E Z KLEEN" RP 9102

by
Henry E. Robinson
Thomas W. Watson
Heating and Air Conditioning Section
Building Technology Division

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

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

PERFORMANCE TESTS OF A CLEANABLE IMPINGEMENT TYPE AIR FILTER "E Z KLEEN" RP 9102

1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of a cleanable impingement type air filter were determined to provide information to assist in the preparation of new air filter specifications.

The test results presented herein were obtained on a specimen filter submitted by its manufacturer at the request of the Public Buildings Service and included determinations of dust-arresting efficiency with two aerosols (atmospheric air and Cottrell precipitate), pressure drop, dirt load and cleanability of the specimen.

2. DESCRIPTION OF THE FILTER SPECIMEN

The filter was manufactured by the Research Products Corporation of Madison, Wisconsin, and was of the cleanable viscid type, 20 x 20 x 2 inches in nominal size. It was identified by nameplate as an "E Z Kleen RP 9102" air filter. The filtering media was composed of many layers of expanded metal (thin aluminum sheet or heavy foil) arranged one after the other, as follows, starting at the upstream face: one 4-1/2 inch square mesh wire grid; two coarse (EM 3/8 x 1/2 inch mesh); one fine (EM 1/4 x 3/8 inch mesh); eleven layers of fine and coarse media arranged alternately; two layers EM 3/8 x 1/2 inch mesh; three layers EM 1/4 x 3/8 inch mesh; one 4-1/2 inch square mesh wire grid. The layers of media were compressed to a thickness of about 1-3/8 inches and surrounded at the edges by an aluminum metal frame. The filter had actual outside dimensions of 19-5/8 x 19-5/8 x 1-7/8 inches, leaving a free opening 18-1/4 inches square (2.31 ft^2 net face area) and weighed 1.8 lb. when clean, without oil.

The manufacturer submitted an adhesive designated as "Filter Coat No. 3" for oiling the filter. This was done in preparation for test by immersing the filter in the liquid and letting excess fluid drain off with the filter standing on edge for a minimum of 20 hours prior to the test. The liquid that was submitted was stated by the manufacturer to consist of one part of "Filter Coat No. 3" and one part of water.

3. TEST METHOD AND PROCEDURE

Efficiency determinations were made by the NBS "Dust-Spot Method" using the following aerosols: (a) outdoor atmospheric air drawn through the laboratory without addition of other dust or contaminant; and (b) Cottrell precipitate, dispersed in the outdoor atmospheric air. The test method is described in the paper "A Test Method for Air Filters" by R. S. Dill (ASHVE Transactions, Vol. 44, P379, 1938). In conducting the tests air was sampled from the test duct at equal rates, from points one foot upstream and eight feet downstream of the filter, and passed through known areas of Whatman No. 41 filter paper. The areas of the filter papers used upstream and downstream, or the times during which the air was sampled upstream and downstream, were selected experimentally so that the change in transmission of light through the two filter paper spots would be about the same. The filter efficiency was calculated by means of the formula,

$$\text{Efficiency, percent} = 100 \left[1 - \frac{A_2}{A_1} \cdot \frac{O_2}{O_1} \cdot \frac{T_1}{T_2} \right]$$

where A represents the dust spot area, O the change in light transmittance of the filter paper as measured before and after the deposition of dust, and T the time during which the air sample was drawn. Subscripts 1 and 2 refer to the upstream and downstream positions, respectively.

Three efficiency-measuring techniques, or modifications based on the above formula were used, depending on the apparent efficiency of the filter with the different aerosols. For the tests made, techniques L, M and N were used, as indicated in Table 2.

All light transmission measurements were made with the photometer illumination at a constant intensity as determined by measurements on a reference of constant transmission characteristics. The filter papers used upstream and downstream were selected to have equal light transmissions when clean.

The efficiency of the filter in arresting particulate matter in atmospheric air was determined by means of two tests of the L and M types, as described above, with the filter clean. Following these, the efficiency of the filter in arresting Cottrell precipitate was measured by means of two N-type tests, after which was begun the process of loading the filter with a mixture of 4 percent of cotton lint and 96 percent of Cottrell precipitate, by weight, separately dispersed in 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. At suitable periods as loading progressed, the efficiency of the filter was determined using Cottrell precipitate in outdoor air. The pressure drop was recorded at intervals during the test. The dirt-loading was continued until the pressure drop increased to approximately 0.50 inch W.G. The efficiency was again determined with Cottrell precipitate and then with atmospheric air as the aerosols.

The filter was then removed from the test duct and cleaned by means of a fine spray of cold water from a hoze nozzle, and rinsed under a low-pressure flow of hot water.

After being dried the filter was reoiled and after draining and drying approximately 22 hours was reinstalled in the test duct for pressure drop measurements at various air flows.

4. TEST RESULTS

Table 1 presents data as to the pressure drop, at several rates of air flow, of the clean and oiled filter, and also of the same filter after it had been loaded with dirt, cleaned and reoiled.

The performance of the filter at 800 cfm is summarized in Table 2, for both aerosols A and C. The performance of the filter in regard to aerosol C (Cottrell precipitate in atmospheric air) is also shown graphically in Figure 1.

The efficiency of the filter in arresting aerosol A (atmospheric particulate matter), both initially, and after its resistance had been increased to 0.5 inch W.G., is indicated in Table 2.

Observation of the filter at the end of the dirt-loading test revealed that the greater part of the arrested dust and lint was found on the upstream face and had not penetrated the media beyond a depth of about 3/4 inch. The downstream face of the media was slightly darkened with dust at the end of the loading test.

The pressure drops recorded in Table 1 indicate that, after the filter had been subjected to loading with the dust-lint mixture and had been cleaned and reoiled, its increase in pressure drop at 800 cfm was 0.013 inch W.G. The weight of the unoiled filter after it had been cleaned and dried following the dirt-loading test was 0.2 lb. greater than that of the unoiled filter initially. The increase of weight of the filter due to oiling was 0.27 lb. initially, and 0.45 lb. for the second oiling. The latter increase was probably due in part to absorption of oil by dirt entrapped in the frameedges. After the tests were completed the media and frame were separated for observation. It was noted there was a deposit of stiff sludge and dirt in the peripheral media behind the edges of the overlapping metal frame that was not removed by the cleaning process. This could account for the increase in weight, and part if not all of the pressure drop increase of the filter. In view of the fact that the filter appeared thoroughly clean in all of the media except at the edges, it is believed it can be considered as satisfactorily cleanable with careful treatment.

After the unit had been removed from the test duct, the section of the duct 5 feet long downstream of the unit, and upstream of a 3/4 inch thick wood strip fastened flat across the bottom of the test duct, was carefully swept out with a fine brush. The amount of material obtained from the duct by this sweeping was 13.8 grams, or 2.5 percent of the dust load reaching the filter, constituting the fall-out in the first 5 feet of the duct from the air passed through the filter, and consisting for the most part of large dust particles.

Cellophane tapes, stretched across the test duct downstream of the filter with the adhesive side facing upstream, indicated upon visual and microscopic examination after exposure to the air stream that large numbers of particles of sizes up to approximately 150 microns, and some lint, had passed through the filter during the dirt-loading tests. Particles much smaller than 5 microns were observed in quantity by microscopic examination of the downstream filter papers obtained in tests with both aerosols.

TABLE 1

PRESSURE DROP OF CLEAN OILED FILTER

Air Flow cfm	Face Velocity fpm	Pressure Drop (1) inch W.G.	Pressure Drop (2) inch W.G.
1200	520	0.190	0.227
1000	433	.133	.156
800	346	.086	.099
600	260	.051	.061

(1) Initial values for the clean filter

(2) Values for the filter after the dirt-loading test, cleaning operation, and reoiling.

TABLE 2

Performance of Filter at 800 CFM

Inlet Aerosol (1)	Total Dirt Load (2) grams	Pressure Drop inch W.G.	Eff. Meas. Technique (3)	Efficiency percent
A	--	0.086	M	0
	--	.086	L	3
C	7	.087	N	53
	14	.088	N	54
	63	.102	N	57
	148	.130	-	--
	211	.152	N	61
	303	.202	N	63
	378	.262	N	65
	471	.364	N	75
	545	.502	N	75
A	545	.513	L	15
	545	.513	L	16

(1) Aerosol A: Particulate matter in atmospheric air at NBS.
Aerosol C: Cottrell precipitate in atmospheric air (1 gram per 1000 cf)

(2) Average mixture: 4% lint, 96% Cottrell precipitate, by weight.

(3) Efficiency-measuring technique:
L: Air sampled at equal rates through equal areas; upstream sampling time selected to yield approximately equal dust-spot opacities both upstream and downstream.
M: Air sampled at equal rates through equal areas for equal times.
N: Air sampled at equal rates for equal times; downstream area selected to obtain approximately equal dust-spot opacities both upstream and downstream.

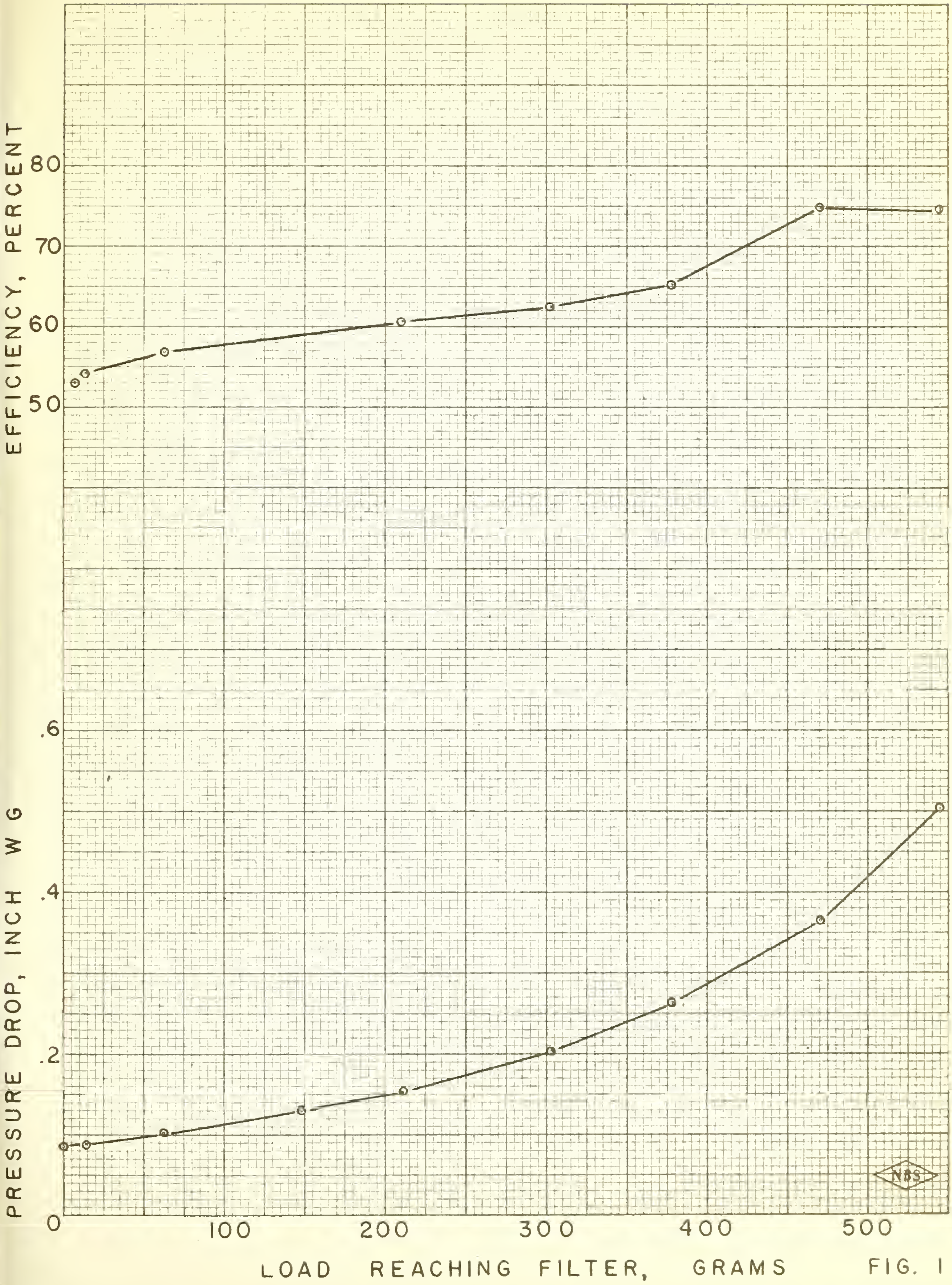
EFFICIENCY, PERCENT
80
70
60
50
PRESSURE DROP, INCH W G
.6
.4
.2
0
100
200
300
400
500
LOAD REACHING FILTER, GRAMS
NBS

FIG. 1

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

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.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.

NBS