NATIONAL BUREAU OF STANDARDS REPORT

4160

PERFORMANCE TESTS OF A DOLLINGER
ELECTRO-STAYNEW PRECIPITATOR

by

Henry E. Robinson
Thomas W. Watson

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

U. S. DEPARTMENT OF COMMERCE
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NBS PROJECT 1000-30-4830

June 20, 1955

NBS REPORT 4160

PERFORMANCE TESTS OF A DOLLINGER ELECTRO-STAYNEW PRECIPITATOR MODEL PJW 102

by

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To

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NBS

U. S. DEPARTMENT OF COMMERCE
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PERFORMANCE TESTS OF A DOLLINGER MODEL PJW 102 ELECTRO-STAYNEW PRECIPITATOR

by

Henry E. Robinson and Thomas W. Watson

1. INTRODUCTION

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of electrostatic air cleaners 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 electrostatic filter unit submitted by its manufacturer at the request of the Public Buildings Service and included determinations of dust-arresting efficiency with three aerosols (atmospheric air, kerosene lamp smoke, and Cottrell precipitate), pressure drop, specific dirt load and cleanability of the specimen.

2. DESCRIPTION OF THE FILTER SPECIMEN

The cleaner was manufactured by the Dollinger Corporation, Rochester, New York, and was of the electrostatic type. It was identified as an "Electro-Staynew Precipitator", Model PJW 102, with one cell, rated velocity 300 feet per minute (1200 cfm total capacity). The power pack had the following nameplate data: "Raytheon Precipitator Power Supply 100 watts; Type Spec. No. 238; 60 cycles;115 volts; 1.5 amps." According to the manufacturer's Bulletin 400, the recommended nominal voltages were ± 6000 volts for the ionizer and -6000 for the collector plates.

The test unit had a housing with actual outside dimensions 25 1/8 x 25 1/8 inches and was 20 7/8 inches long. It was rated as having about four sq. ft. of transverse area, i.e., 1200 cfm air delivery at 300 fpm velocity.

The upstream and downstream faces had flanges 30 inches square matching those of the duct of the test apparatus. The face openings were approximately 24

inches square both upstream and downstream. The downstream face was adapted to receive a nominal 24x24x2-inch after-filter which for this unit was a 23 9/16 x 23 9/16 x 2-inch DPV-2 cleanable impingement type air filter manufactured by the Dollinger Corporation.

The filter cell of the test unit was 23 3/4 inches in height, 17 5/8 inches in length, and 23 inches in width, and contained 61 aluminum or steel plates spaced approximately 5/16 inch apart, presenting a total surface area of approximately 185 square feet.

The manufacturer furnished an adhesive (a water-emulsifying oil) designed as "Pingene 400", with which the collector plates were oiled by spraying them from both the upstream and downstream face. The after-filter was oiled in preparation for the test by immersing the filter in the oil and letting the excess drain off with the filter standing on edge for 18 hours prior to the test.

The power pack, connected to a 115-volt 60-cycle supply, was adjusted in accordance with instructions of the manufacturer to recommended settings prior to the tests; the ionizer and plate voltages that resulted were measured by means of an accurate electrostatic voltmeter. As indicated in the manufacturer's bulletin, the total ionizer voltage differential was equal to the difference of the positive and negative voltages above ground furnished by the power pack.

3. TEST METHOD AND PROCEDURE

Efficiency determinations were made by the NBS "Dust-Spot Method" using the following aerosols: (a) outdoor air drawn through the laboratory without addition of other dust or contaminant; (b) kerosene lamp smoke; and (c) 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). The test duct and arrangement are shown in Figure 1. A baffle made of two 3-inch wide slats was located in the duct about 3½ ft downstream of the test assembly to intermix the air discharged from it.

For these tests, the unit was installed in the test duct and carefully sealed to prevent inleakage of air. The desired rate of air flow through the air cleaner 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 air cleaner assembly at equal rates and passed through known areas of Whatman No. 41 filter paper. For the atmospheric air and oil lamp smoke tests, the samples were drawn at equal rates through equal areas of filter paper (3/4-inch diameter spots). The downstream sample was drawn continuously during the test; the upstream sample was drawn intermittently in a number of one-minute periods uniformly distributed over the duration of the test, aggregating one-tenth of the downstream sampling period. Under these conditions an efficiency of 90 percent would be indicated if the upstream and downstream dust-spots on the filter papers had the same opacity, as indicated by the change in the light transmissions of the dust-spot areas before and after the sample was drawn, which were determined by means of a photometer using transmitted light. The filter papers used in the upstream and downstream positions were selected to have the same light transmission readings when clean. If the opacities of the dust-spots differed, the efficiency was calculated by means of the formula

$$\text{Efficiency, percent} = 100\left[1 - \frac{t_1}{t_2} \cdot \frac{O_2}{O_1}\right] = 100 - 10\left(\frac{O_2}{O_1}\right)$$

where O_1 and O_2 were the opacities of the dust-spots upstream and downstream, respectively, and t_1 and t_2 were the aggregate times during which the upstream and downstream samples, respectively, were drawn.

For the efficiency tests with Cottrell precipitate as the aerosol, the samples upstream and downstream were drawn at equal rates and for equal times but unequal dust-spot areas were used to obtain opacities that were approximately equal. If the opacities of the dust-spots differed, the value of the efficiency was calculated by means of the formula above, with the ratio A_2/A_1 substituted for the ratio t_1/t_2, where A_2 and A_1 were the areas of the dust-spots downstream and upstream respectively.

The following procedure was employed in these tests. After the clean and oiled unit had been installed in the test duct, and all discoverable air leaks into its housing had been sealed, its input and output voltages were adjusted to values recommended by a representative of the

manufacturer: (input 115 volts; ionizer 13.6 kv total; plates-6.8 kv). Three determinations of the efficiency of the clean unit were made at the rated velocity, using as the aerosol outdoor air drawn into the test duct through a nearby open window. A determination of efficiency with the unit not energized was also made. Following these, single determinations were made using outdoor air at velocities 20 percent greater, and 20 percent less than the rated velocity.

Next, three efficiency determinations were made at rated velocity, using as the aerosol outdoor air with addition of kerosene smoke generated by an open lamp flame near the inlet to the test duct.

Following these, three efficiency determinations were made at rated velocity, using as an aerosol outdoor air in which was dispersed Cottrell precipitate at a concentration of one gram per thousand cubic feet of air. When these had been obtained, the process was begun of loading the unit with a mixture of four percent cotton lint and 96 percent Cottrell precipitate, by weight, separately dispersed 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; the lint was dispersed into the air stream through an aspirator operating at approximately 35 psi inlet air pressure. At suitable periods as loading progressed, the efficiency of the unit was determined using 100 percent Cottrell precipitate in outdoor air. In these tests, and during the loading process, the rate of feed of the dispersant was one gram per thousand cubic feet of air. The pressure drop and the ionizer and plate voltages of the unit were recorded at intervals during the tests. The dirt-loading process was continued until about 611 grams of the lint and Cottrell precipitate mixture had been fed (i.e., 2/3 gram per CFM of unit rating).

At suitable periods as the dirt-loading process progressed, strips of transparent cellophane adhesive tape (3/4 inch wide) were stretched vertically across the test duct near its axis, with the adhesive side facing upstream. Tapes were located at three positions (1) 12 inches upstream, (2) 15 inches downstream, and (3) eight ft downstream, of the test unit; the tapes at stations (1) and (3) were in the same longitudinal positions in the test duct as the inlets to the upstream and downstream sampling tubes. The adhesive surface of such a tape captured a sample of the particulate

matter in the air flowing past it, and after suitable times of exposure to the aerosol, scrutiny of the tapes by eye and with a microscope afforded considerable information as to the vertical distribution, and the nature, number, and size of the particles caught at the various stations. Photographic enlargements (10X) by transmitted light were made of sections of the tapes corresponding to a position at mid-height in the test duct.

At the end of the tests, the filter cell was removed from the test unit and cleaned by means of a stream of cold water from a high pressure hose nozzle, directed at and into the cell plates from both ends of the unit.

4. TEST RESULTS

A summary of the test data, giving efficiencies in percent with the three aerosols, and the pressure drop of the complete unit including the after-filter, in inch W.G., at rates of air flow corresponding to various face velocities, is given in Table 1. Also, a summary of the test data obtained in the dirt-loading test conducted at the rated face velocity of 300 fpm is given in Table 2.

Photographs No. 1, 2 and 3 included in this report are 10X enlargements of the center 3/4x1-inch section of each of the cellophane tapes located at the three similarly-numbered stations described under Test Method and Procedure. The tapes were exposed at their respective stations simultaneously during the dirt-loading test for a period in which 124 grams of mixture were fed to the test unit. This exposure was during the interval in which the dirt-load increased from 38 to 162 grams, as shown in Table 2. After exposure, the tapes were carefully removed from the test duct for photographing and microscopic study.

Throughout the tests with atmospheric air there were only four observed incidents of electrical sparking or flashing in the unit audible to the ear. There was no instance of sparking or flashing during the kerosene lamp smoke tests. However, during the Cottrell precipitate and lint loading test electrical sparking occurred intermittently, the frequency increasing from two to three times per hour at the start to as much as 50 to 100 times per hour at 300 to 500 grams of load, and reducing to about 20 to 30 times per hour at the end of the loading test.

5. SUMMARY

A. Performance

The efficiency of the air cleaner in arresting the particulate matter existent in atmospheric air drawn through the unit varied considerably with the face velocity at which it was operated, as shown in Table 1. At the rated velocity (300 fpm), the average efficiency on atmospheric air (91.2 percent), and that on oil lamp smoke (91.6 percent), were very nearly the same. The efficiencies are reported to three significant figures obtained from the test data. In reporting thus, however, it is considered desirable to point out that an uncertainty on the order of one or two percent is possible in determining efficiencies, although in these results the differences between comparable efficiency values were consistently of lesser magnitude with only one exception.

It is noted in Table 2 that in the dirt-loading test, the pressure drop of the complete unit increased by 0.023 inch W.G. for a total input dirt-load of 811 grams. This rise was due chiefly to an increase in the pressure drop of the after-filter, as a result of an accumulation of cotton lint and of comparatively large particles of Cottrell precipitate on its media.

As recorded in Table 2, the ionizer voltage showed a decrease of 0.8 kv and the plate voltage a decrease of 1.2 kv at about 500 grams of load, however, as the dirt load was increased further, the ionizer and plate voltages increased to approximately their initial values. The efficiency of the unit with Cottrell precipitate as the aerosol remained at a high level, never falling below 97.4 percent and ending with a value of 98.3 percent, approximately equal to that at the start of the loading test. An efficiency determination made with atmospheric air at the end of the dirt-loading test indicated that the unit was approximately as efficient (within about two percent) on this aerosol when heavily laden with dirt, as it was when clean.

B. Cleanability

The filter was subjected to the cleaning process described under Test Method and Procedure. No difficulty was experienced in thoroughly cleaning the ionizer and collector sections of the unit, using moderate care.

C. General

On completion of the dirt-loading tests, the unit was removed from the test duct and examined. The ionizer structure and bars, and the insulators, were generally coated with a moderate layer of dust and lint. Dirt deposits were heaviest on the upstream edges and first two or three inches of the collector plates, the thickness of the deposits being up to about 1/32 inch. The heaviest deposits were observed on the leading edges of the negative plates. A continuous, but thinner, layer of dirt was deposited over the remaining area of the collector plates, extending to the aft edges. Considerable bridging of lint fibers from one collector plate to another, spanning the gap between them, was observed; such bridging appeared to be most extensive from the center of the unit downstream to the aft edges of the plates.

The upstream face of the after-filter revealed considerable deposits of lint, somewhat concentrated in six vertical strips each about two inches wide. The after-filter media was approximately uniformly darkened by a dust deposit on its upstream face, and slightly darkened by dust visible on its downstream face.

The dirt (dust) deposits on the electrostatic unit, and on the after-filter appeared to be well saturated with oil. After the unit had been removed from the test duct, the section downstream of the unit was carefully swept out with a fine brush. The amount of material obtained from this sweeping was 0.3 gram.

The cellophane tape samples obtained at stations (1), (2) and (3), as shown in Photographs No. 1, 2 and 3, respectively, indicate in a general way the performance of the complete unit. Photograph No. 1 shows many particles under five microns in actual size, and a distribution of larger particles up to a few as large as 400 microns, as well as many fibers of lint. (In these photographs, 1/16 inch corresponds to an actual dimension of about 160 microns). Photograph No. 2, for the tape 15 inches downstream of the unit, shows a few large particles up to about 150 microns in size, but very few fine dust particles considering their number upstream of the unit. Photograph No. 3, for the tape eight feet downstream of the unit, shows an absence of the larger particles of Photograph 2, which apparently settled out of the air stream.

Comparison of the numbers of particles on the upstream and downstream tapes indicates, in an obvious way, a high order of efficiency for the unit in arresting Cottrell precipitate, as is also indicated by the discoloration test results presented in Table 2. The latter results show a considerably higher efficiency for the unit when Cottrell precipitate was being received in the air stream than when the aerosol was outdoor air or kerosene lamp smoke. The overall efficiency of the unit on particles of the sizes found in Cottrell precipitate appears therefore to be better than on the finer particles in outdoor air or kerosene smoke. Nevertheless, the downstream tapes, and the deposits on the after-filter, show that a few quite large particles of dust escaped beyond the electrostatic unit. Whether the large particles were passed through the unit because they were not arrested at all, or were caught and later dislodged from the collector plates by electrical sparking, is not known from these tests.

As the photographs show, a few large particles passed unarrested through the after-filter. Assuming that one of the functions of the after-filter is to arrest as much as possible of the material escaping the electrostatic unit, the arrestance characteristics of the after filter are of major importance in determining the presence or absence, in the air leaving the complete unit, of such particulate matter as is shown in the downstream tape photographs.

Table 1

Face Velocity	Inlet Aerosol*	Total Ionizer Voltage	Plate Voltage	Pressure Drop	Duration of Test	Efficiency
fpm		kv	kv	inch W.G.	minutes	percent
300	A	0	0	0.083	35	12.5**
300	A	13.6	6.8	0.083	180	90.0
300	A	13.6	6.8	.083	180	91.9
300	A	13.6	6.8	.083	180	91.6
360	A	13.6	6.8	.113	180	87.2
240	A	13.6	6.8	.059	180	94.9
300	S	13.6	6.8	.084	180	91.7
300	S	13.6	6.8	.084	180	91.8
300	S	13.6	6.8	.084	180	91.4
300	C	13.6	6.8	.083	12	97.5
300	C	13.6	6.8	.083	10	99.4
300	C	13.6	6.8	.083	10	98.4

*A = Particulate matter in atmospheric air at NBS.
S = Kerosene lamp smoke in atmospheric air.
C = Cottrell precipitate in atmospheric air (1 gram/1000 CF).
** Since unit was not energized, the efficiency was chiefly that of the after-filter.

Table 2

Face Velocity	Dirt Load*	Total Ionizer Voltage	Plate Voltage	Pressure Drop	Efficiency**
fpm	grams	kv	kv	inch W.G.	percent
300	36	13.6	6.8	0.084	98.4 (avg)
	175	13.6	6.8	.089	98.3
	349	13.8	6.9	.090	98.3
	361	13.0	6.1	.088	97.8
	524	12.8	5.6	.091	97.4
	649	13.7	6.7	.093	98.1
	761	13.1	5.9	.099	-
	811	13.8	6.9	.107	98.3
	811	13.8	6.9	.107	89.2***

*Average mixture: 3.9% lint, 96.1% Cottrell precipitate by weight.
**Efficiency determined with 100% Cottrell precipitate.
***Efficiency determined with atmospheric air (aerosol A), as in Table 1, with the unit dirty.

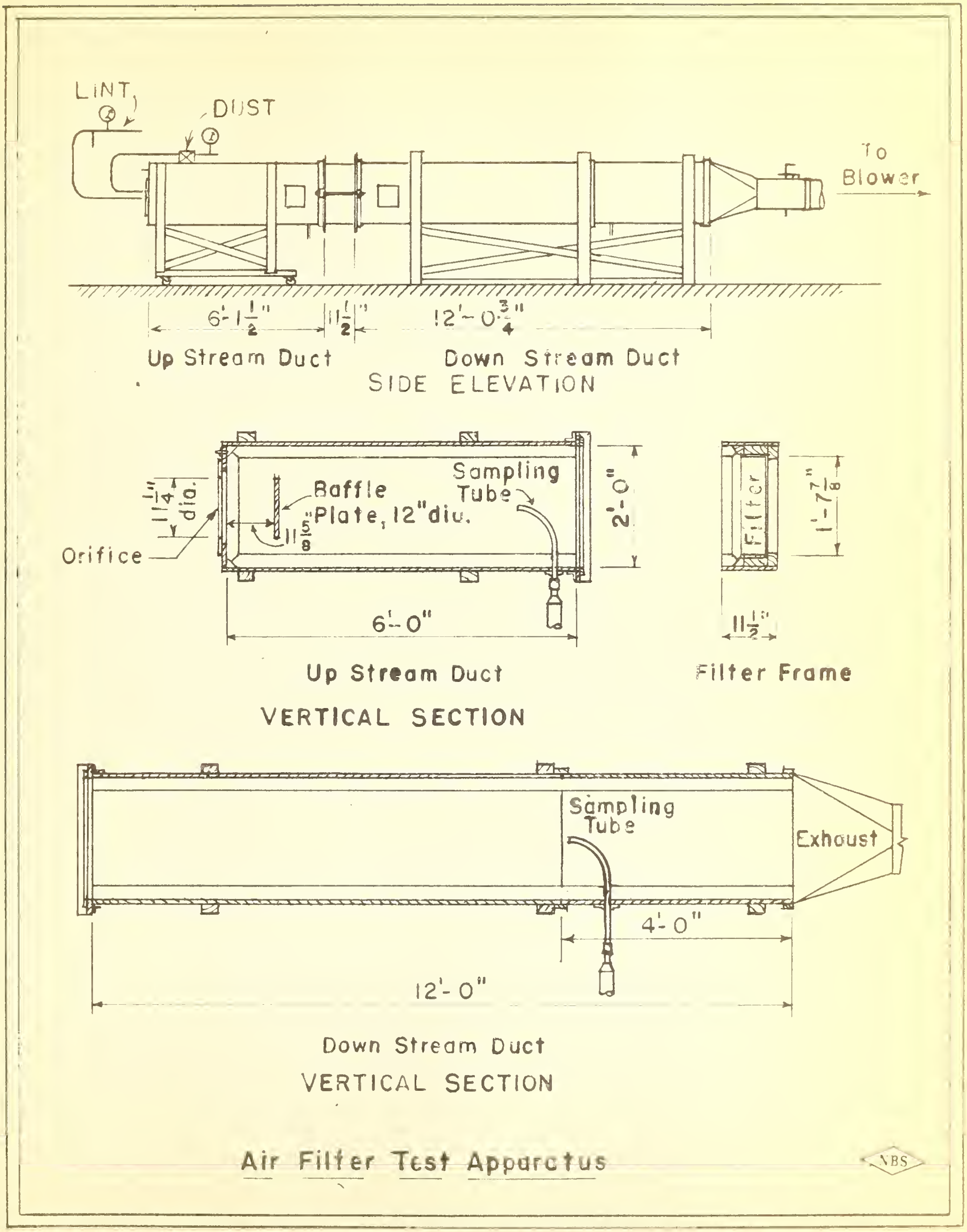
LINT
DUST
To Blower
6'-1 1/2"
11 1/2"
12'-0 3/4"
Up Stream Duct
Down Stream Duct
SIDE ELEVATION
1 1/4" dia.
Baffle Plate, 12" dia.
11 5/8"
Sampling Tube
2'-0"
Orifice
6'-0"
Filter
1'-7 7/8"
11 1/2"
Up Stream Duct
Filter Frame
VERTICAL SECTION
Sampling Tube
Exhaust
4'-0"
12'-0"
Down Stream Duct
VERTICAL SECTION
Air Filter Test Apparctus
NBS

Fig. 1

Photograph No. 1

Photograph N .

Photo[illegible] 5

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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