NATIONAL BUREAU OF STANDARDS REPORT

6952

PERFORMANCE TEST OF AN ELECTRO-CELL ELECTROSTATIC AIR CLEANER, MODEL 2-24

manufactured by
American Air Filter Company
Louisville, Kentucky

by

Carl W. Coblentz and Paul R. Achenbach

Report to

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

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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C. W. Coblentz and P. R. Achenbach
Mechanical Systems Section
Building Research Division

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1. Introduction

At the request of the Public Buildings Service, General Services Administration, the performance characteristics of an Electro-Cell electrostatic air cleaner were determined. The scope of this examination included the determination of the arrestance of the particulate matter in the laboratory air and of Cottrell precipitate, the pressure drop, and the dust-holding capacity of the specimen.

2. Description of Test Specimen

The device was manufactured and supplied for test purposes by the American Air Filter Company of Louisville, Kentucky, and was their high-velocity Electro-Cell, Model 2-24.

The outside dimensions of the collector cell were 19 3/4 in. high, by 23 3/4 in. wide, and 10 in. deep. There were seven ionizer wires. The grounded elements between these ionizer wires were extensions of some of the grounded plates with cut-outs provided for the intermediate ionizer supports. The cell had 63 charged plates and 62 grounded plates, each 5 9/16 x 19 3/4 in. in size. Six of these grounded plates, the extensions of which served as grounded elements between the ionizer wires, were 4 in. longer than the other plates, and had a thickness of 0.0437 in., whereas all other plates were 0.0218 in. thick. The plates were arranged 5/32 in. center-to-center. The effective or net face area of the collector cell was 2.87 square feet and the gross face area was 3.26 square feet. The cell was equipped with a 2-in. thick after filter, American Air Filter Co. type Amer-Glas. The adhesive used on both the after filter and the plates was designated as type NCC (Viscosine); it appeared to be a light detergent oil.

The power pack supplied with the unit was built by the General Electric Co. It was their type SG-3V and was designed for 13.4 KV ionizer voltage and 4.0 KV plate voltage.

3. Test Method and Procedure

The arrestance measurements were made in accordance with the "NBS Dust Spot Method" described in a paper by R. S. Dill and entitled "A Test Method for Air Filters" (ASHVE Transactions, Vol. 44, p. 379, 1938).

For test purposes, the collector cell was installed in the test apparatus and carefully sealed to prevent inward leakage of air except through the measuring orifice. The desired rate of air flow through the filter was established and samples of air were drawn from the center points of the test duct two feet upstream and eight feet downstream of the test specimen at equal rates and passed through known areas of Whatman No. 41 filter paper. The change of the opacity of these areas was determined with a sensitive photometer which measured the light transmission of the same spot on each sampling paper before and after the test. The two sampling papers used for each test were selected to have the same light transmission readings when clean.

For determining the arrestance of the filter, with Cottrell precipitate as the test dust, different size areas of sampling papers were used upstream and downstream of the filter in order to obtain a similar increase of opacity on both sampling papers.

For each arrestance determination with Cottrell precipitate, the upstream sample of the aerosol was collected on one filter paper for about half of the test period and on a second filter paper during the remainder of the test period. The downstream sampling paper collected the dust for the entire test. This method was used to avoid too large differences in the dust spots when determining Cottrell precipitate arrestance values on the order of 99 percent. The arrestance, A (in percent), was then calculated by the formula:

$$A = \left(1 - \frac{S_D}{S_U} \times \frac{\Delta D}{\Delta U_1 + \Delta U_2}\right) \times 100$$

where S_U and S_D are the upstream and downstream sampling areas and ΔU_1, ΔU_2, and ΔD the observed changes in the opacity of the two upstream and one downstream sampling papers, respectively.

For determining the arrestance of the particulate matter in the laboratory air, equal sampling areas were used for the upstream and downstream samplers. A similar increase of the opacity of the upstream and downstream filter papers was obtained by passing the sampling air through the upstream paper only part of the time while operating the downstream sampler continuously. This was accomplished by installing one solenoid valve in the upstream sampling line and another one as a by-pass for the sampler and first solenoid valve. The valves were operated by an electric timer and a relay so that one was open while the other one was closed during any desired percentage of the 5-minute timer cycle, reversing the position of the two valves during the remainder of the cycle. The arrestance, A (in percent), was then determined with the following formula:

$$A = 100 - T \times \frac{\Delta D}{\Delta U}$$

where T is the percentage of time during which air was drawn through the upstream sampler, ΔU and ΔD being the changes of opacity of the sampling papers, as previously indicated.

After installing the device, the power pack was connected to the laboratory electric supply line and suitable transformer taps were selected. A measurement of the static voltages with a line voltage of 117 volts showed 13.8 KV ionizer voltage and 4.3 KV plate voltage. By means of a variable voltage transformer, the line voltage was adjusted, during subsequent readings of the static voltage, to 117 ± 1/4 volts, but was allowed to drift during the test runs.

Six arrestance determinations were made immediately after installation with air flow rates in a range from 1312 to 2300 cfm. Thereafter, several arrestance measurements were made with Cottrell precipitate. A total of 16 arrestance measurements were made during the loading period while 1119 grams of dust and lint were introduced into the system. The loading of the test specimen was concluded when 2/3 gram of dust had been introduced for each cfm rated air flow (1094 grams).

4. Test Results

A summary of the test results is presented in Table 1 which shows the air flow rates, dust load, pressure drop, and arrestance values observed with the particulate matter in the laboratory air as well as for Cottrell precipitate as the aerosol. The effect of the dust load on the pressure drop and on the arrestance of the particulate matter in the laboratory air are plotted in Fig. 1. The effect of the air flow rate on the arrestance of the device with clean plates is shown in Fig. 2. The curves in these two graphs are drawn as smooth curves approximating the lines of least mean square distances.

Table 1

Performance of
American Air Filter Co. Electro-Cell 2-24

Air Flow Rate cfm	Dust Load grams	Pressure Drop in. W. G.	Arrestance %	Aerosol **
1312	0	0.181	98.2*	A
1640	0	0.266	95.9*	A
1968	0	0.288	93.1	A
2300	0	0.378	88.5	A
1640	10	0.275	98.9	C
1640	228	0.300	99.4	C
1640	477	0.332	99.3	C
1640	477	0.332	95.1	A
1640	684	0.367	94.4	A
1640	705	0.375	99.1	C
1640	892	0.419	93.1	A
1640	953	0.434	99.3	C
1640	1099	0.478	92.0	A
1640	1119	0.480	99.1	C

* Average of two tests.

** A - Particulate matter in laboratory air.
C - Cottrell precipitate in laboratory air.

At the rated flow rate of 1640 cfm, the pressure drop increased from an initial value of 0.266 in. W.G. to a final value of 0.480 in. W.G. after a dust load of 1119 grams had been introduced into the system. During this time, the arrestance of atmospheric dust decreased from 95.9 percent to 92.0 percent. The arrestance of Cottrell precipitate has not been plotted but was determined in six test runs to be in the range from 98.9 to 99.5 percent, averaging 99.2 percent.

The relation of arrestance of the particulate matter in the laboratory air to air flow rate for the clean unit is plotted in Fig. 2 and shows a decrease from 98.2 percent at 1312 cfm air flow to 88.5 percent at 2300 cfm air flow rate.

An examination of the collector cell after the conclusion of the test showed that all plates were evenly covered with a light layer of dust. The number of electrical discharges observed did not exceed 18 per minute and was considerably less during most of the performance test.

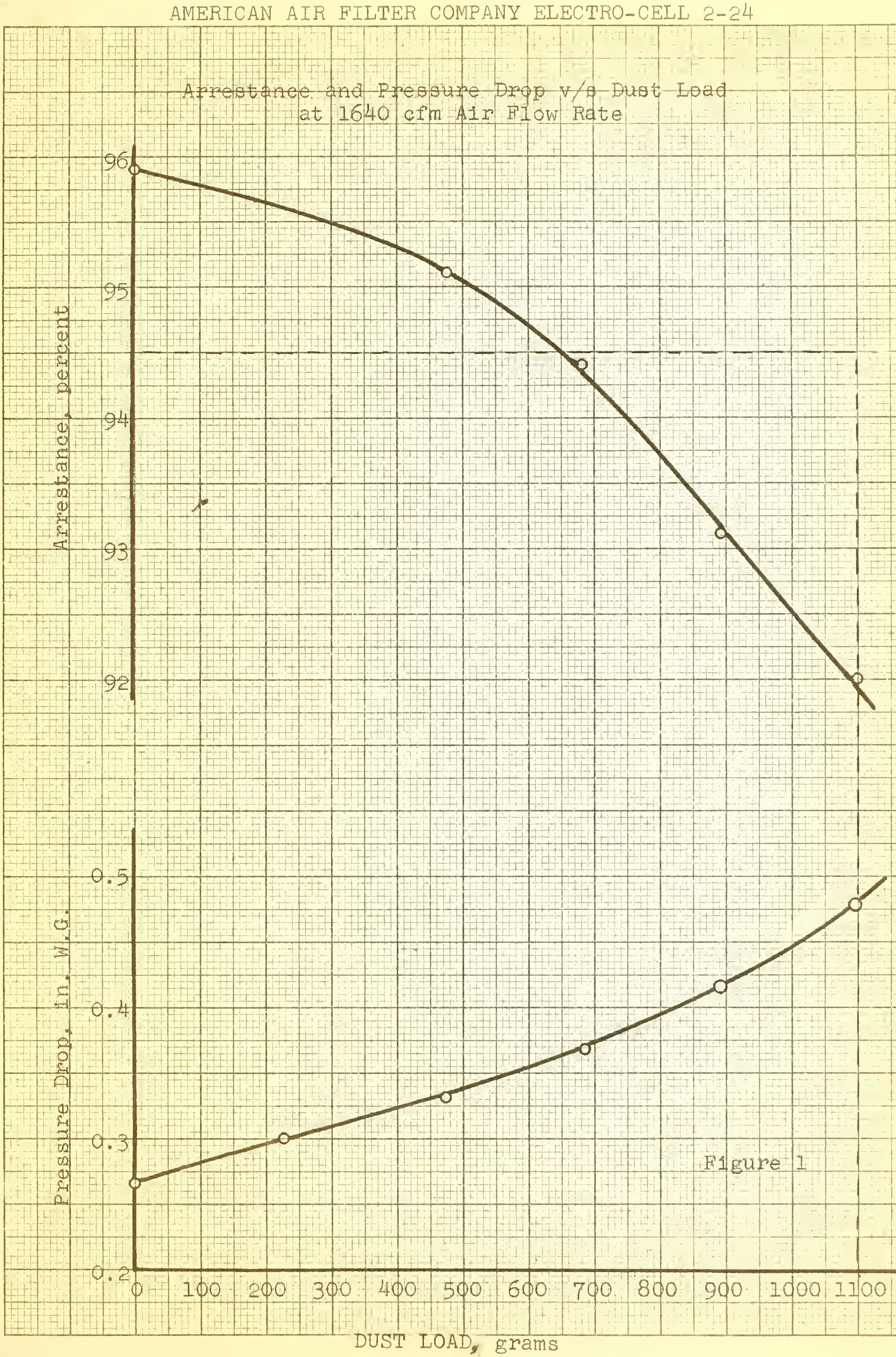
AMERICAN AIR FILTER COMPANY ELECTRO-CELL 2-24
Arrestance and Pressure Drop v/s Dust Load
at 1640 cfm Air Flow Rate
Arrestance, percent
96
95
94
93
92
Pressure Drop, in. W.G.
0.5
0.4
0.3
0.2
0
100
200
300
400
500
600
700
800
900
1000
1100
DUST LOAD, grams

Figure 1

AMERICAN AIR FILTER COMPANY ELECTRO-CELL 2-24

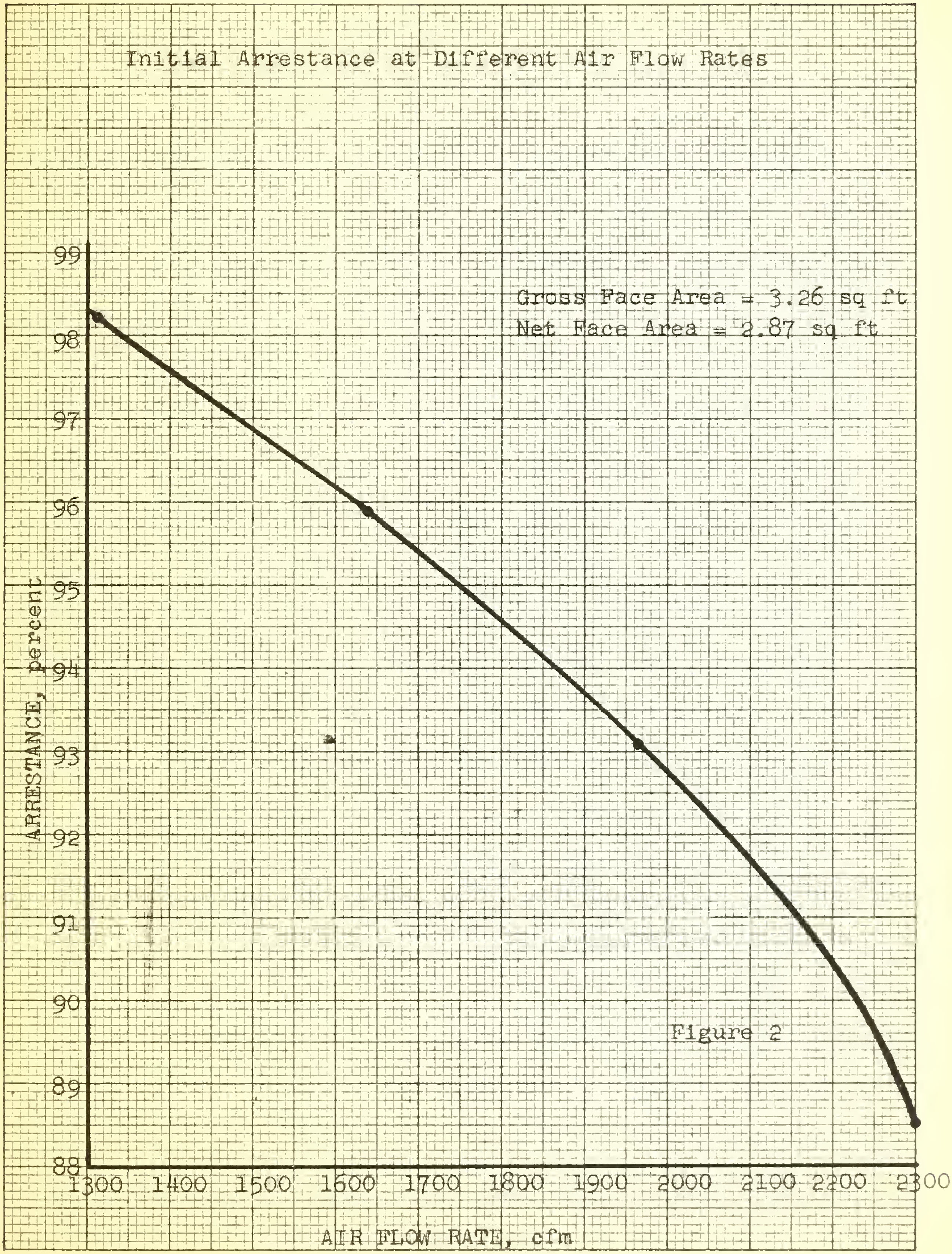

Figure 2

U.S. DEPARTMENT OF COMMERCE
Frederick H. Mueller, *Secretary*

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

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

Washington, D.C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measuments. Dielectrics.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

Heat. Temperature Physics. Heat Measurement. Cryogenic Physics. Rheology. Molecular Kinetics. Free Radicals Research. Equation of State. Statistical Physics. Molecular Spectrocopy.

Radiation Physics. X-ray. Radioactivity. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics. Radiation Theory.

Chemistry. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Molecular Structure and Properties of Gases. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Combustion Controls.

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

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

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

Building Technology. Structural Engineering. Fire Protection. Air Conditioning, Heating, and Refrigeration. Floor, Roof, and Wall Coverings. Codes and Safety Standards. Heat Transfer. Concreting Materials.

Applied Mathematics. Numerical Analysis Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analog Systems. Applications Engineering.

Atomic Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

- Office of Weights and Measures.

Boulder, Colorado

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionosphere Research. Regular Prediction Services. Sun-Earth Relationships. VHF Research. Radio Warning Services. Airglow and Aurora. Radio Astronomy and Arctic Propagation.

Radio Propagation Engineering. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Propagation-Terrain Effects. Radio-Meteorology. Lower Atmospheric Physics.

Radio Standards. High-Frequency Electrical Standards. Radio Broadcast Service. Radio and Microwave Materials. Electronic Calibration Center. Microwave Circuit Standards.

Radio Communication and Systems. Low Frequency and Very Low Frequency Research. High Frequency and Very High Frequency Research. Modulation Systems. Antenna Research. Navigation Systems. Systems Analysis. Field Operations.

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