VERIFICATION OF POLARISCOPIC APPARATUS

Department of Commerce and Labor
BUREAU OF STANDARDS
Washington

BUREAU CIRCULAR No. 12

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The functions of the Bureau of Standards may be briefly stated as follows: The custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions, with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials. The Bureau will also furnish such information concerning standards, methods of measurement, physical constants, and the properties of materials as may be at its disposal, and is authorized to exercise its functions for the Government of the United States, for State or municipal governments within the United States, for scientific societies, educational institutions, firms, corporations, or individuals engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments.

For all comparisons, calibrations, tests, or investigations, except those performed for the Government of the United States or State governments, a reasonable fee will be charged.

RANGE OF TESTS.

Tests on polariscopic apparatus include the verification of the following:

1. POLARISCOPES.—(*a*) Polariscopes with scales graduated in circular degrees, (*b*) polariscopes with scales graduated in both circular and Ventzke degrees, (*c*) saccharimeters with scales graduated in Ventzke degrees.
2. Quartz control plates.
3. Observation tubes, (*a*) of fixed length, (*b*) of variable length.
4. Flasks.
5. Thermometers.
6. Weights.

1. POLARISCOPES.

GENERAL INSTRUCTIONS.—When a polariscope or saccharimeter is submitted for test, it is desirable that the request be accompanied by a statement of the conditions under which the instrument is to be used, the use to which it will be put, the character of the light source, and the temperature at which it will be used. Only when such data are given is it possible to realize in the test approximately the same conditions as in the actual use of the instrument, and to indicate the order of accuracy that may be obtained in practice. Such data also enable suggestions to be made as to modifications in the use of the instrument that may lead to more satisfactory results.

Unless otherwise requested, polariscopes and saccharimeters will be verified at 20° C. Saccharimeters will be tested on the basis that the 100° (Ventzke) point is determined by

26 grams of anhydrous sucrose weighed in air with brass weights and made up to a volume of 100 cc (100 cc equals the volume of 100 g of water at 4° C weighed in a vacuum). The number of points of the scale verified will depend upon the character of the instrument and the purpose for which it is to be used.

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SCHEDULE 43.—POLARISCOPES AND SACCHARIMETERS.

(*a*) For verifying five points on polariscope graduated in circular degrees	$5.00
(*b*) For verifying five points on polariscope graduated in both circular and Ventzke degrees	10.00
(*c*) For verifying five points on saccharimeter	5.00

2. QUARTZ CONTROL PLATES.

The rotation of quartz control plates will be measured in circular degrees at 20° C. The rotation will be given for either the wave length 589.25 $\mu\mu$ or 546.1 $\mu\mu$. 589.25 $\mu\mu$ is the wave length corresponding to the two sodium lines from incandescent sodium vapor. 546.1 $\mu\mu$ is the wave length of the so-called "yellow-green" line of incandescent mercury vapor. Unless otherwise requested, the rotation values for quartz control plates will be given for the wave length 589.25 $\mu\mu$.

Control plates should be mounted loosely in a metal frame. The amount of play in every direction should be as small as possible, but the metal should exert no pressure upon the plate. Certificates will not be given for plates mounted with wax, but plates so mounted will be tested and a statement of the rotation issued. The Bureau reserves the right to reject any plate showing faults which tend to make it unreliable.

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SCHEDULE 44.—QUARTZ CONTROL PLATES.

(*a*) Verification of quartz plate in either circular or Ventzke degrees	$2.00

3. OBSERVATION TUBES.

The Bureau will accept both glass and metal polariscope observation tubes for test. An internal diameter of not less than 9 mm is desirable.

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SCHEDULE 45.—POLARISCOPIC OBSERVATION TUBES.

(*a*) For verifying tubes from 25 mm to 600 mm in length	$0.25
(*b*) For verifying tubes with variable length a fee will be charged proportional to the character and amount of work required.	

4. FLASKS.[1]

The cross section of all flasks must be circular throughout and the neck must merge into the body of the flask so gradually that there will be no hindrance to uniform drainage. Flasks that are manifestly fragile or otherwise defective in construction will be rejected. The part on which the graduation mark is placed must be transparent, of uniform thickness, and free from striæ.

The liter will be employed as the unit of capacity, or in some cases its submultiple, the one one-thousandth liter, called the cubic centimeter. The liter is defined as the volume of 1 kilogram of water at 4° C.

[1] For further details regarding the testing of volumetric apparatus, see Bureau Circular No. 9.

Twenty degrees Centigrade is accepted by the Bureau as the standard temperature. An extra charge will be made for the verification of flasks standard at any other temperature.

Flasks must be plainly marked with capacity in liters or cubic centimeters and the temperature for which they are graduated. At the point where the graduation mark is placed the neck of a flask must have an internal diameter not greater than the maximum nor less than the minimum diameter given in the following table:

Capacity of flask ---------- liters	2	1	0.5	0.25	0.2	0.1	0.05	0.025	0.01
Diameter of flask: Maximum ---millimeters	25	20	18	15	13	12	10	8	8
Diameter of flask: Minimum --------do------	18	14	12	10	9	8	6	6	6

The graduation mark must be placed not less than 6 cm from the upper end and not less than 2 cm from the lower end of the neck of a flask larger than 100 cc, and not less than 3 cm from the upper end or 1 cm from the lower end of the neck of a flask not larger than 100 cc. The graduation mark must extend entirely around the neck.

The bottom of a flask must be slightly reentrant, and the flask must be of such form that drainage can take place from the whole interior surface at the same time. The neck of a flask must be perpendicular to a plane tangent to the bottom. The flask must stand solidly when placed on a horizontal plane.

The errors of flasks must not exceed the following limits:

Capacity.	Limit of Error.
cc	*cc*
2,000	0.5
1,000	.3
500	.15
250	.1
200	.1
100	.08
50	.05
25	.03
10	.01

Flasks of other capacities shall not have errors greater than those of the next smaller sizes here given.

Methods of Testing.—Flasks will be tested by means of water and the capacity will therefore be expressed as the volume of water the vessel will contain when at its standard temperature. The neck of the flask will be dry above the meniscus when read, except for the wetting necessary to secure a normal meniscus. The reading will be made where the neck is cut by a plane perpendicular to the axis of the flask and tangent to the meniscus at its lowest point.

Official Stamp.—Flasks which fulfill the above requirements will receive the official stamp of the Bureau. The stamp consists of the letters "U. S." and the last two figures of the year date, the whole being surrounded by a circle. Thus for 1906 the stamp will be:

The stamp will be placed on the neck immediately above the mark.

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SCHEDULE 23 (PART).—FLASKS.

Flasks, "To contain," of 25, 50, 100, 200 cc capacity:	
(*a*) For testing and stamping similar pieces, 10 or less, each	$0.25
(*b*) For testing and stamping similar pieces in excess of 10, each additional piece	.20
(*c*) For testing, stamping, and certificate of correction for similar pieces, 10 or less, each	.35
(*d*) For testing, stamping, and certificate of correction for similar pieces in excess of 10, each additional piece	.25
Flasks of 500, 1,000, 2,000 cc capacity:	
(*e*) For testing and stamping similar pieces, 10 or less, each	.30
(*f*) For testing and stamping similar pieces in excess of 10, each additional piece	.25
(*g*) For testing, stamping, and certificate of correction for similar pieces, 10 or less, each	.40
(*h*) For testing, stamping, and certificate of correction for similar pieces in excess of 10, each additional piece	.30

5. THERMOMETERS.[2]

GENERAL INSTRUCTIONS.—Thermometers should be made of a suitable hard glass having small "zero depression" and small thermal hysteresis. Among the glasses best fulfilling these requirements are 16^{III} Jena normal glass, 59^{III} Jena borosilicate glass, and French hard glass. It is only important that the bulbs of the thermometers be made of a suitable hard glass; for the stem of the thermometer a softer glass with white enamel back may be used. For ordinary laboratory thermometers, when an order of accuracy of 0°.02 or 0°.03 C is sufficient, the stem should be so graduated by the maker that the indications of the thermometer will be in close agreement with the indications of the gas thermometer which is taken as the standard.

It is highly desirable that the ice point (0° C or 32° F) be found on the scale so that variations in the volume of the bulb can be easily detected and allowed for. The divisions on the stem should be fine and clear, the width of the graduation marks in no case exceeding 0.2 of a scale division, and should be numbered at such frequent intervals and in such a way that identification of any graduation mark is not unnecessarily difficult. Where the thermometers are provided with metal backs which carry a graduation, the stem of the thermometer should nevertheless be graduated. The thermometer should be securely and firmly fastened and should have a fiducial mark on the stem coinciding with a mark on the metal back, so that any relative displacement may be controlled. If the thermometer is of the inclosed scale (Einschluss) type, such fiducial mark should be found on the outer glass tube inclosing the scale and capillary stem of the thermometer. The bore of the stem and the spacing of the graduation marks should be uniform and free from such irregularities as would produce errors in the indication by amounts exceeding the limits otherwise set by the type of thermometer.

LABORATORY AND SPECIAL THERMOMETERS.—Under this head may be broadly grouped most of the thermometers of the usual types, including secondary and working standards whose order of accuracy is 0°.01 or 0°.02 C, and ordinary thermometers whose order of accuracy is 1 or 2 degrees. Illustrations of special thermometers are maxima and minima thermometers, calorimetric, hysometric, deep-sea, and other thermometers used for special purposes.

[2] Further details of the construction and precautions in use of mercurial thermometers are given in Bureau Circular No. 8.

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SCHEDULE 32.—LABORATORY AND SPECIAL THERMOMETERS.

(*a*) Determinations of the corrections in the interval −30° to +100° C to an order of accuracy of 0°.01 or 0°.02 C, or as accurately as the construction of the thermometer warrants, for each point tested	$0.20
(*b*) Same as above, in lots of 6 or over	.10
(*c*) Determination of corrections to nearest 0°.1 or 0°.2 C, for each point tested	.15
(*d*) Same as above, in lots of 12 or over	.075
(*e*) Determination of the corrections to within 0°.1 or 0°.2 C from 100° C up to about 250° C, and somewhat less accurately at higher temperatures, for each point tested	.50

INDUSTRIAL THERMOMETERS.—For information concerning the testing of high-temperature and industrial thermometers, see Bureau Circular No. 8.

6. WEIGHTS.[3]

CLASSIFICATION.—The following three classes of weights will be accepted by the Bureau for regular test and certification: Class A. Reference standards; Class B. Working standards; Class C. Accurate commercial weights. The Bureau reserves the right to reject any weights showing faults which have a tendency to make them unreliable.

CLASS B WEIGHTS.—The weights used in connection with polariscopic work are assumed to fall within the class designated as Class B. This class includes weights suitable as standards for makers of scales and weights, for city or district sealers, and for chemical and other scientific work.

FORMS OF CERTIFICATES.—For weights of Class B this Bureau will give two forms of certificates—(*a*) certificates of values, which will give the value of each weight; (*b*) certificates of classification, which will merely certify that the weights are within the tolerance errors established by the Bureau. For example, they will be certified as Class B weights if the errors are within those allowed for that class.

EXTENT OF TEST.—For certificate of classification the test will include only a single weighing for each weight, except where the errors are very close to the limit: for certificate of values a sufficient number of weighings of each weight will be made to insure the accuracy of the corrections.

CERTIFICATE AND MARKING.—Values for individual weights will be given approximately as shown in the tables below. Upon request weights not coated with lacquer or other material liable to be injured by so doing will be marked with the seal of the Bureau and a capital B if they fulfill the requirements for weights of this class.

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SCHEDULE 12.—CLASS B. WORKING STANDARDS OF MASS.

	CERTIFICATE OF VALUE.	CERTIFICATE OF CLASSIFICATION.
	Each.	*Each.*
For single weights	(*a*) $0.80	(*b*) $0.40
For weights in connected series	(*c*) .50	(*d*) .25
For adjustment—(I) when of two pieces; (II) when of one piece but not requiring replating	(*e*) .75	(*f*) .75

[3] For further details concerning the testing of weights, see Bureau Circular No. 3.

TABLE OF TOLERANCES, CLASS B.

Weight.	Tolerance.	Values given to.
500 g	5 mg	1 mg
200	2	.1
100	1	.1
50	.5	.1
20	.2	.01
10	.2	.01
5	.2	.01
2	.1	.01
1	.1	.01
500 mg	.08	.001
200	.06	.001
100	.05	.001
50	.05	.001
20	.04	.001
10	.04	.001
5	.03	.001
2	.02	.001
1	.02	.001
.5	.01	.001
.2	.01	.001
.1	.01	.001

No weights smaller than 10 milligrams will be stamped with the seal of the Bureau, and other weights to be stamped must be so constructed that it can be done readily.

Inaccurate Weights.—When weights are not sufficiently accurate or otherwise fail to conform to the requirements of the Bureau for weights of the class to which they are intended to belong, the Bureau will, unless previously requested to do otherwise, notify the one who submitted the weights, and will await further instructions. If the only fault is that they are not sufficiently accurate, they may be (1) *reclassified*, if they come within the requirements of a lower class, (2) *readjusted*, or (3) *returned*. Sets of weights must be treated as a whole. Incorrect weights belonging to a set may be replaced before a test is completed, but the Bureau will not give a classification certificate for part of a set.

Form of Certificate.—The certificate furnished by the Bureau of Standards will contain the following data: (*a*) Description or identification marks of article or instrument; (*b*) Bureau of Standards test number and certification number where allowed; (*c*) Name of party for whom apparatus is compared; (*d*) Temperature and other conditions of the test; (*e*) Table of corrected values or of desired corrections; (*f*) Date of certification; (*g*) Seal of the Bureau and signature of the Director; (*h*) Special remarks where necessary.

The Bureau reserves the right to reject any apparatus on points affecting its accuracy not covered by the regulations.

SPECIAL DIRECTIONS.

Application for Test.—The request for verification of any apparatus should state fully the nature of the test and other conditions, if any, which it is desired should be observed.

Identification Marks.—Both the instruments and the packages in which they are shipped should be plainly marked to facilitate identification, preferably with the name of the manufacturer or shipper, and a special reference number should be given to the article.

Glassware Breakage.—No risk of breakage will be assumed by the Bureau. All possible care will be taken in handling the apparatus submitted for test, but a certain amount of breakage is unavoidable and must be borne by the owner.

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Shipping Directions.—Instruments should be securely packed in cases or packages which may be used in returning them to the owner. Tops of cases should be screwed down whenever possible. Transportation charges are payable by the party desiring the test, and should be prepaid. Unless otherwise arranged, articles will be returned by express "collect."

Address.—Articles and correspondence should be addressed simply, "Bureau of Standards, Department of Commerce and Labor, Washington, D. C." Delays incident to other forms of address will thus be avoided.

Articles delivered in person or by messenger should be left at the office of the Bureau and should be accompanied by a written request for the verification.

Remittances.—Fees may be remitted by money order or check drawn to the order of the "Bureau of Standards," and should be sent with the request for test whenever practicable. Delays in forwarding fees involve corresponding delays in the return of articles tested, as articles are held until the fees due thereon have been paid.

It is the desire of the Bureau to cooperate with manufacturers, scientists, and others in bringing about more satisfactory conditions relative to the weights, measures, measuring instruments, and physical constants used in polariscopic work and to place at the disposal of those interested such information relative to these subjects as may be in its possession. Persons interested are invited to visit the laboratories of the Bureau, where leading types of polariscopes may be seen in operation.

S. W. Stratton,
Director.

Approved:
James Rudolph Garfield,
Acting Secretary.

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