U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

TESTING OF GLASS VOLUMETRIC APPARATUS

CIRCULAR C434 (Supersedes C9)

U. S. DEPARTMENT OF COMMERCE
JESSE H. JONES, Secretary
NATIONAL BUREAU OF STANDARDS
LYMAN J. BRIGGS, Director

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[Supersedes Circular C9]

TESTING OF GLASS VOLUMETRIC APPARATUS

By
ELMER L. PEFFER and GRACE C. MULLIGAN

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PREFACE

The purpose of this Circular is to present to manufacturers and others the information necessary for the design, construction, and verification of glass volumetric apparatus and to indicate the facilities available at the Bureau for this verification. The specifications and tolerances given herein apply to burettes, flasks, pipettes, and other glass volumetric apparatus of precision quality.

Specifications with reference to design, workmanship, dimensions, inscriptions, etc., are given in detail.

LYMAN J. BRIGGS, *Director.*

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By Elmer L. Peffer and Grace C. Mulligan

ABSTRACT

This Circular contains specifications and tolerances for glass volumetric apparatus of precision grade. Detailed information is given as to dimensions, type of graduations, inscriptions, and tolerances for burettes, flasks, cylinders, and certain kinds of special apparatus.

Instructions are given for the method of reading, the test liquid used, the method of test, and the importance of cleanliness of apparatus. An outline of the tests performed, reports of test, and directions for submitting apparatus are included.

CONTENTS

I. STANDARD SPECIFICATIONS FOR GLASS VOLUMETRIC APPARATUS [1]

The primary purpose of these specifications is to define the requisite qualifications for precision apparatus.

The Bureau aims to encourage excellence in quality by cooperating with makers and users of apparatus, and to this end endeavors to assist manufacturers in establishing standards and perfecting their methods. In order that users of standardized apparatus may fully benefit by the facilities of the Bureau, it is necessary for them when purchasing apparatus to be submitted for test to require that the apparatus shall comply with the specifications of the Bureau. By admitting for test only apparatus conforming to these standards, the work of testing is confined to apparatus whose utility is sufficient to justify the labor expended in its accurate calibration. Certain of the specifications, such as those regarding quality of glass and process of annealing before calibration, are largely dependent on the integrity of the maker for their fulfillment. Only by supporting conscientious makers, in giving consideration first to quality and second to cost, can users of standardized apparatus secure a high degree of excellence.

1. TYPES OF APPARATUS WHICH WILL BE REGULARLY ADMITTED FOR TEST

Measuring flasks; measuring cylinders, with or without subdivisions; transfer pipettes and capacity pipettes, without subdivisions; burettes, measuring pipettes, and dilution pipettes, with partial or complete subdivisions; specific gravity flasks and Babcock test bottles and pipettes.

2. GENERAL SPECIFICATIONS

(a) UNITS OF CAPACITY

The *liter*, defined as the volume occupied by a quantity of pure water at 4° C having a mass of 1 kilogram, and the one-thousandth part of the liter, called the *milliliter* or *cubic centimeter*,[2] are employed as units of capacity.

(b) STANDARD TEMPERATURE

Twenty degrees centigrade is regarded by the Bureau as the standard temperature for glass volumetric apparatus, and an extra charge is made for testing apparatus graduated for use at other temperatures.

(c) MATERIAL AND ANNEALING

The material should be of best quality glass, transparent and free from striæ, should adequately resist chemical action, and have small thermal hysteresis. All apparatus should be thoroughly annealed at 400° C and allowed to cool slowly for 24 hours before being graduated.

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[1] Convenient tables for use in testing volumetric apparatus are published in Circular No. 19 of this Bureau.

[2] The cubic centimeter is not exactly the one-thousandth part of the liter, but the difference is seldom of consequence in volumetric analysis; 1 milliliter = 1.000028 cubic centimeters. (La Création du Bureau International des Poids et Mesures et son Oeuvre, Ch. Éd. Guillaume, p. 258, 1927.) In all volumetric work the unit of volume employed is the milliliter and not the cubic centimeter, but in this country it is often designated by the letters "cc".

(d) DESIGN AND WORKMANSHIP

The cross section must be circular and the shape must permit complete emptying and drainage.

Instruments having a base or foot must stand solidly on a level surface, and the base must be of such size that the instruments will stand on a plane inclined 15° to the horizontal.

Stoppers and stopcocks must be so ground as to work easily and prevent leakage.

The parts on which graduations are placed must be cylindrical for at least 1 cm on each side of every mark, but elsewhere may be enlarged to secure the desired capacities in convenient lengths.

The graduations should be of uniform width, continuous, and finely but distinctly etched, and must be perpendicular to the axis and parallel to the base of the apparatus.

All graduations must extend at least halfway around; and on subdivided apparatus at least every tenth mark, and on undivided apparatus all marks, must extend completely around the circumference. Subdivided apparatus must be provided with a sufficient number of lines of suitable length, to facilitate reading.

The clear space between two adjacent marks most be not less than 1 mm wide. The spacing of marks on completely subdivided apparatus must show no evident irregularities, and sufficient divisions must be numbered to readily indicate the intended capacity of any interval. Apparatus which is manifestly fragile or otherwise defective in construction will not be accepted.

Two scales will not be permitted on the same piece of apparatus except in the case of the special double-scale cylindrical graduate herein described. For example, apparatus should not be graduated in both liquid ounces and milliliters. In the case of two units, one of which is an exact multiple of the other, such, for example, as drams and liquid ounces, there is no objection to having the 8-dram, 16-dram, etc., marked, respectively, 1 liquid ounce, 2 liquid ounces, etc., provided that the two series of numbers are placed on opposite sides of the apparatus and the value of each is suitably indicated.

(e) INSCRIPTIONS

Every instrument must bear in permanent legible characters the capacity, the temperature at which it is to be used, the method of use—that is, whether to contain or to deliver— and on instruments which deliver through an outflow nozzle, the time required to empty the total nominal capacity with unrestricted outflow must be likewise indicated. Inscriptions may be etched or engraved but shall not be scratched on the apparatus.

Every instrument should bear the name or trade-mark of the maker. Every instrument must bear a permanent identification number, and detachable parts, such as stoppers, stopcocks, etc., belonging thereto must bear the same number. Interchangeable ground-glass parts shall be marked on both members with the proper standard taper symbol, $\overline{\$}$, followed by the size designation. (In accordance with Commercial Standard CS21–39).

Figure 1 illustrates several arrangements of designating marks which are considered suitable.

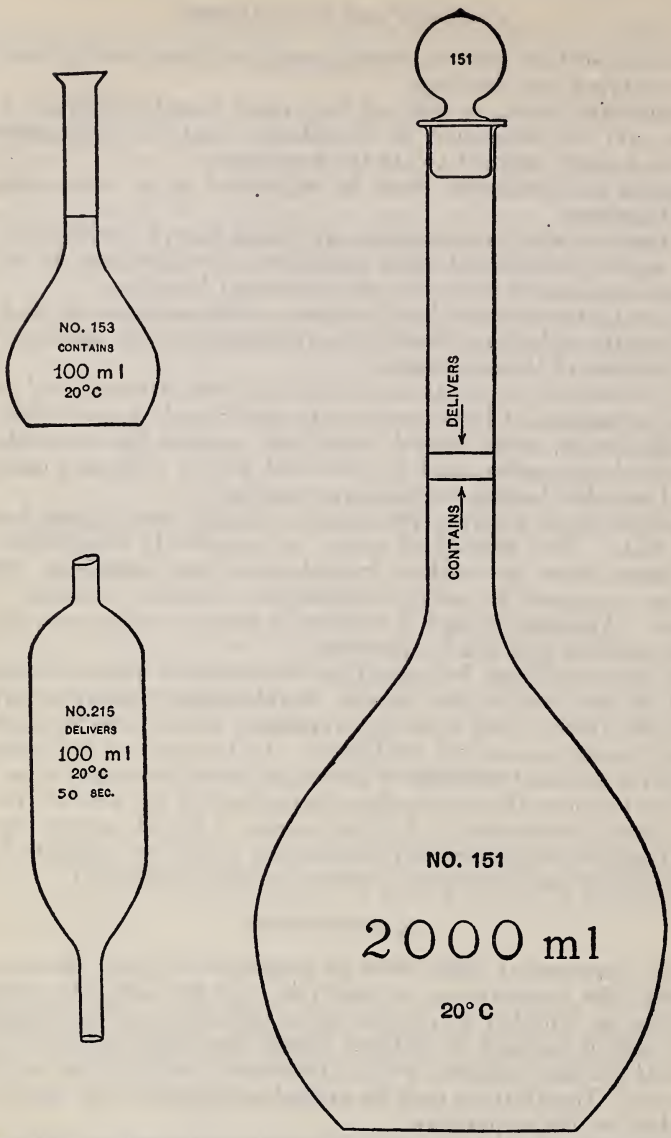

FIGURE 1.—*Examples of inscriptions suitable for volumetric apparatus.*

3. SPECIAL REQUIREMENTS

(a) FLASKS

At the capacity mark or marks on a flask the inside diameter must be within the following limits:

Diameter	Capacity of flask (in milliliters) up to and including—											
	25	50	100	200	250	500	1,000	2,000	3,000	4,000	5,000	6,000
	mm	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*	*mm*
Maximum	8	10	12	14	15	18	20	25	30	35	40	45
Minimum	6	6	8	9	10	12	14	18	20	22	25	30

The neck of a flask must not be contracted above the graduation mark.

The capacity mark on any flask shall be not nearer the end of the cylindrical portion of the neck than is specified below:

Capacity	Distance from upper end	Distance from lower end
	cm	*cm*
100 ml or less	3	1
More than 100 ml	6	2

A flask may be graduated both *to contain* and *to deliver*, provided the intention of the different marks is clearly indicated and provided the distance between the two marks is not less than 1 mm.

(b) CYLINDERS

Cylinders graduated either to contain or to deliver will be accepted for test.

A double-scale graduate—that is, with a scale reading both up and down the length of the graduate—will not be accepted for test, as it is obvious that the same graduate can not be correct both to contain and to deliver.

The inside diameter of cylinders must be not more than one-fifth the graduated length.

The relation of the height to the diameter must be such that the graduation marks are not less than 1 mm apart, and also that the graduated height is at least five times the inside diameter. In the case of the 10-ml cylinder subdivided to 0.1 ml and the 25-ml cylinder subdivided to 0.2 ml, it will be found necessary to make the graduated height considerably more than five times the inside diameter in order to give a separation of 1 mm to the graduation marks. On the larger cylinders, subdivided as indicated, the graduation marks will be sufficiently separated if the graduated height is five times the inside diameter. Subdivision lines may be omitted between the base of the cylinder and the first numbered line but this interval shall be either ungraduated or completely graduated.

Ordinary cylindrical graduates are usually subdivided as shown in figure 2 except as noted in the legend thereto.

The smallest diameter of the necks of cylinders with stoppers shall be not less than specified below:

Capacity (in milliliters)	5	10	25	50	100	200	500	1,000	2,000
Minimum diameter of neck (in millimeters)	6	7	8	9	10	12	15	18	20

STANDARD CYLINDRICAL GRADUATES IN UNITED STATES CUSTOMARY UNITS.—In view of the difficulty experienced by weights and measures officials in securing satisfactory graduates, it has been thought advisable to prepare detailed specifications for a complete set of cylindrical graduates in United States customary units.

The specifications here presented are intended to cover those graduates most often needed by weights and measures officials in the discharge of their duties, and while for certain special purposes

FIGURE 2.—*Standard cylindrical graduates in metric units.*

To avoid excessive height, the subdivisions on 10-ml, 25-ml, and 50-ml cylinders should be not less than 0.2 ml, 0.5 ml, and 1.0 ml, respectively. When 25-ml and 250-ml cylinders are subdivided as shown above, it is customary in commercial practice to number the fifth line from the base and every tenth line thereafter, ending with the top line. The numbered lines extend completely around the circumference.

they may not be found satisfactory it is believed that most of the ordinary needs of the officials will be met.

The graduates most often required are the following: One dram (60 minims), subdivided to 2 minims; 2 dram (120 minims), subdivided to 5 minims; 1 liquid ounce, subdivided to ¼ dram (15 minims); 2 liquid ounce, subdivided to 1/16 ounce; 4 liquid ounce, subdivided to 1/16 or ⅛ ounce; 8 liquid ounce, subdivided to ⅛ ounce; 16 liquid ounce, subdivided to ¼ ounce; 32 liquid ounce, subdivided to ½ ounce; 3 cubic inch, subdivided to 1/10 cubic inch; 10 cubic inch, subdivided to 2/10 cubic inch; and 35 cubic inch, subdivided to ½ cubic inch.

In the past this last-named graduate has sometimes been further subdivided to ¼, ½, and 1 pint, either liquid or dry, and sometimes both. In that case the number and closeness of the graduations are likely to lead to confusion and error in the use of the graduate. In the future this graduate will not be accepted by the Bureau for test. Since it is considered important by most inspectors to have a single graduate which may be used for testing both liquid and dry measures, it has been thought advisable to provide for such a graduate. For that purpose a cylinder may be made up with divisions of only the ¼, ½, and 1 liquid pint, and ¼, ½, and 1 dry pint, leaving the remainder of the cylinder entirely blank, except for the necessary inscription. The major divisions of the cylinder will then not be obscured and confused by the small subdivisions. Such a cylinder may be used to test both liquid and dry measures by using with it the usual auxiliary tolerance graduate. For this purpose the 2-ounce or 4-ounce graduate, subdivided to ½ dram, and the 3-cubic inch subdivided to 1/10 cubic inch will be found convenient.

It might be said in this connection that when a large graduate is used in the test of measures by pouring from the graduate into the measure, a small auxiliary graduate should always be used for determining the excess or deficiency of the measure, as the subdivisions of the large graduate are not sufficiently fine for the purpose. Also the first few divisions at the base of a graduate are difficult to read and are not always accurate.

Basis of Graduation.—All graduates herein described and for which specifications are herein given should be graduated in accordance with the following relations:

8 liquid drams =1 liquid ounce.
32 liquid ounces=1 liquid quart.
4 liquid quarts =1 U. S. liquid gallon=231 cubic inches.
1 liquid quart =57.75 cubic inches.
1 dry quart =67.20 cubic inches.

For conversion to the metric system, the relation is

1 liquid ounce=29.5729 milliliters.

Graduates may be calibrated either to contain or to deliver, but on each graduate the method of use must be stated. (See Inscription.)

Graduates that are to be used dry to receive liquids and measure them in the graduate should be calibrated to contain.

Graduates that are to be used to pour water from the graduate into other measures, and those which are to be used wet to contain

water from other measures should be calibrated to deliver. For example, a graduate that is to be used in testing milk bottles, either by pouring water from the graduate into the bottles or from the bottles into the graduate without drying the graduate between bottles, should be calibrated to deliver. After having been wet the graduate will, on successive fillings and emptyings, deliver the same quantity that is poured into it.

In ordering graduates the purchaser should consider the use to which they are to be put and should specify accordingly whether they should be calibrated to contain or to deliver.

SPECIFICATIONS.—The same general specifications apply to these graduates as to other volumetric apparatus described in this circular.

The relation of the height to the diameter of the cylinder should be such that the highest graduation will come within the following limits:

Total nominal capacity	Distance of highest graduation from top		Total nominal capacity	Distance of highest graduation from top	
	Minimum	Maximum		Minimum	Maximum
	cm	*cm*		*cm*	*cm*
60 minims	2	4	16 liquid ounces	5	10
120 minims	2	4	32 liquid ounces	5	10
1 liquid ounce	2	5	3 cubic inches	3	5
2 liquid ounces	3	5	10 cubic inches	4	8
4 liquid ounces	3	6	35 cubic inches	5	10
8 liquid ounces	4	8			

The graduations should be of uniform width, continuous, and finely but distinctly etched or engraved, and must be perpendicular to the axis of the cylinder.

All graduations must extend at least halfway around and at least every tenth graduation entirely around the cylinder.

The space between two adjacent graduations must never be less than 1 mm, and in general should be from 2 to 5 mm, depending upon the size of the graduate.

Inscription.—Each graduate must bear in permanent and legible characters its capacity, the temperature at which it is to be used, the method of use—that is, whether to contain or to deliver—and an identification number. It is desirable, also, that the name of the manufacturer be placed on each graduate.

The numbers indicating the capacity of the graduate at its different points should be placed immediately above the marks to which they refer.

Subdivisions and Length of Lines.—The 60-minim graduate, subdivided to 2 minims, should have each 2-minim graduation extend at least halfway around the cylinder. Each 10-minim graduation should extend entirely around and should be numbered.

The 120-minim graduate, subdivided to 5 minims, should have each 5-minim graduation extend at least halfway around, each 10 minims about three-fifths around, and each 20 minims entirely around. Each 20-minim graduation should be numbered.

The 1-ounce (8 drams) graduate, subdivided to ¼ dram (15 minims), should have each ¼-dram graduation extend at least halfway around, each ½ dram about three-fifths around, and each dram entirely

around the cylinder. Each dram graduation should be numbered.

The 2-ounce graduate, subdivided to $\frac{1}{16}$ ounce should have each $\frac{1}{16}$-ounce graduation extend at least halfway around, each $\frac{1}{8}$-ounce graduation about three-fifths around, and each $\frac{1}{4}$-ounce graduation entirely around the cylinder. Each $\frac{1}{2}$-ounce graduation should be numbered.

The 4-ounce graduate, if subdivided to $\frac{1}{16}$ ounce, should have the same arrangement and length of graduations as the 2-ounce, except that only each $\frac{1}{2}$-ounce graduation should extend entirely around and only each ounce should be numbered.

If subdivided only to $\frac{1}{8}$ ounce, then each $\frac{1}{8}$-ounce graduation should extend at least halfway around, and each $\frac{1}{2}$ ounce and 1 ounce entirely around, and each 1-ounce graduation should be numbered.

The 8-ounce graduate, subdivided to $\frac{1}{8}$ ounce, should have each $\frac{1}{8}$-ounce graduation extend at least halfway around, each $\frac{1}{2}$-ounce graduation about three-fifths around, and each 1-ounce graduation entirely around and numbered.

The 16-ounce graduate, subdivided to $\frac{1}{4}$ ounce, should have each $\frac{1}{4}$-ounce graduation extend at least halfway around, each 1 ounce about three-fifths around, and each 2 ounce entirely around and numbered.

The 32-ounce graduate, subdivided to $\frac{1}{2}$ ounce, should have each $\frac{1}{2}$-ounce graduation extend at least halfway around, each 1 ounce about three-fifths around, and each 4 ounce entirely around and numbered.

The 3-cubic-inch graduate, subdivided to $\frac{1}{10}$ cubic inch, should have each $\frac{1}{10}$-cubic-inch graduation extend at least halfway around, each $\frac{5}{10}$-cubic-inch graduation three-fifths around, and each 1-cubic-inch graduation entirely around and numbered.

The 10-cubic-inch graduate, subdivided to $\frac{2}{10}$ cubic inch, should have each $\frac{2}{10}$-cubic-inch graduation extend at least halfway around, and each 1-cubic-inch graduation entirely around and numbered.

The 35-cubic-inch graduate, subdivided to $\frac{1}{2}$ cubic inch, should have each $\frac{1}{2}$-cubic-inch graduation extend at least halfway around, each 1 cubic inch about three-fifths around, and each 5 cubic inch entirely around and numbered.

The tolerances to be allowed on cylinders are shown under "Tolerances," page 20.

The special double-scale graduate with subdivisions of $\frac{1}{4}$, $\frac{1}{2}$, and 1 liquid pint, and $\frac{1}{4}$, $\frac{1}{2}$, and 1 dry pint should have all the graduations extend entirely around and be numbered, the numbers for the liquid pint and for the dry pint being placed on opposite sides of the cylinder.

(c) TRANSFER PIPETTES

Pipettes for delivering a single volume are designated "transfer" pipettes.

The suction tube of each transfer pipette must be at least 16 cm long, and the delivery tube must be not less than 3 cm nor more than 25 cm long. The top of the suction tube must be finished with a smooth plane surface, at right angles to the axis.

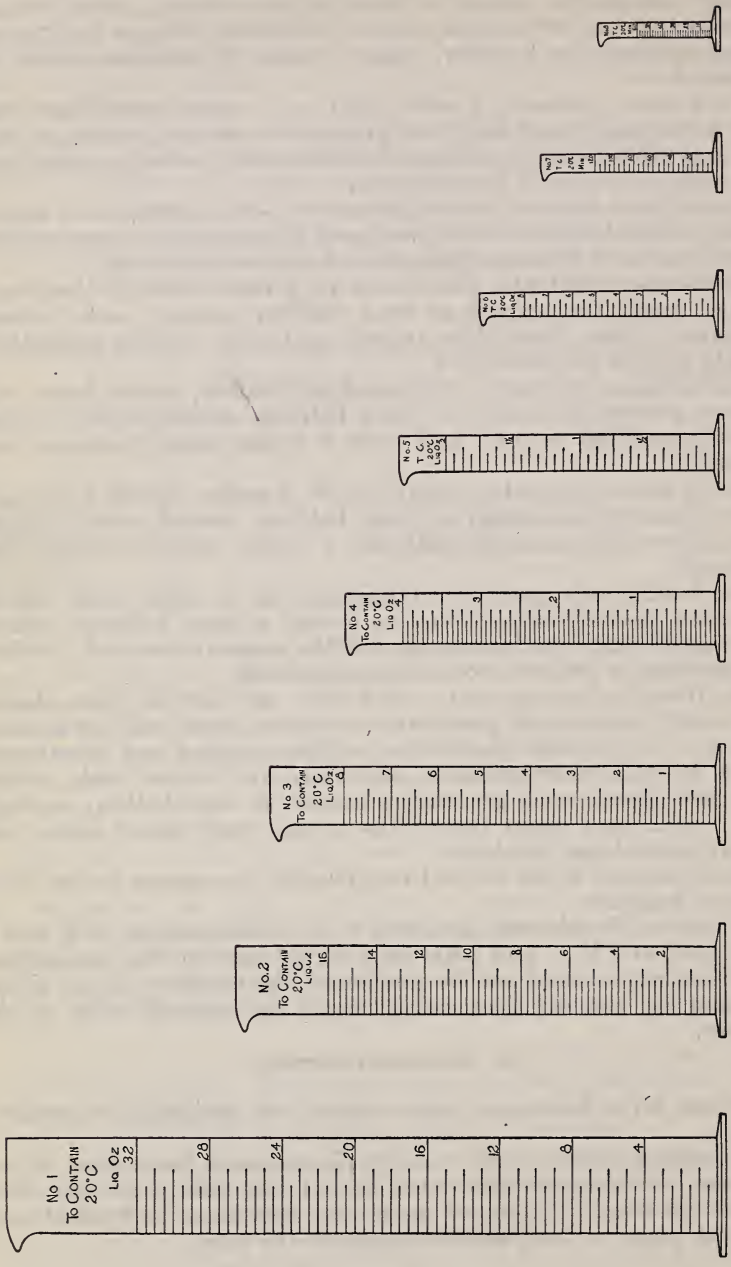

FIGURE 3.—*Standard cylindrical graduates in customary units.*

The inside diameter of any transfer pipette at the capacity mark must be not less than 2 mm and must not exceed the following limits:

Capacity of pipettes (in milliliters) up to and including	25	50	200
Diameter (in millimeters)	4	5	6

The outside diameter of the suction and delivery tubes of transfer pipettes, exclusive of the tip, must be not less than 5 mm.

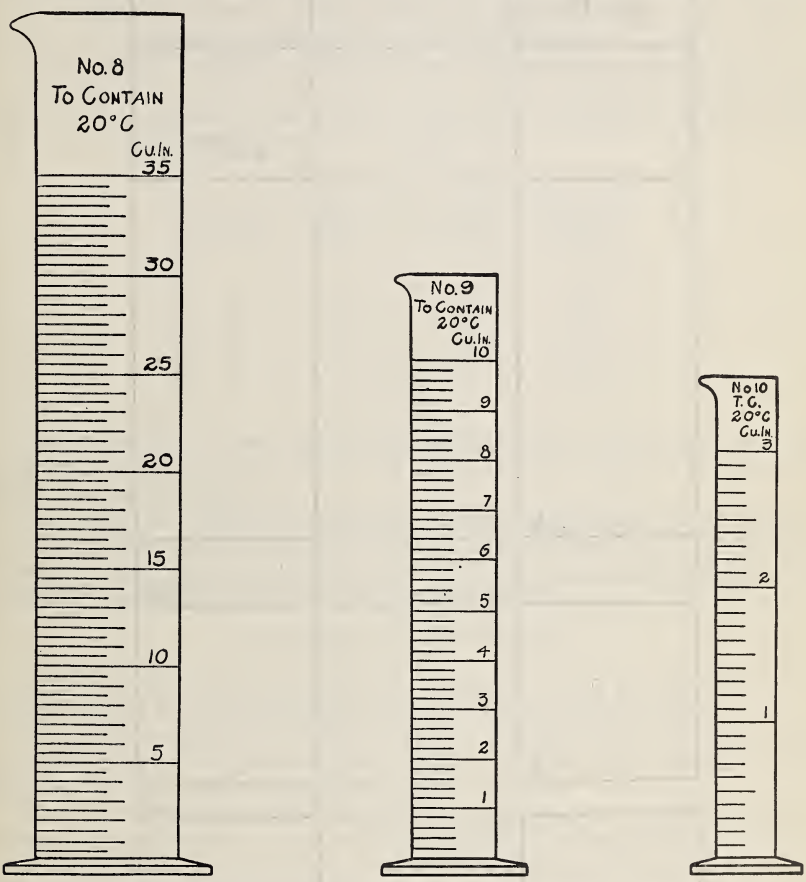

FIGURE 4.—*Standard cylindrical graduates in cubic inches.*

The capacity mark on transfer pipettes must be not more than 6 cm from the bulb.

The outlet of any transfer pipette must be of such size that the free outflow shall last not more than 1 minute and not less than the following for the respective sizes:

Capacity (in milliliters) up to and including	5	10	50	100	200
Outflow time (in seconds)	15	20	30	40	50

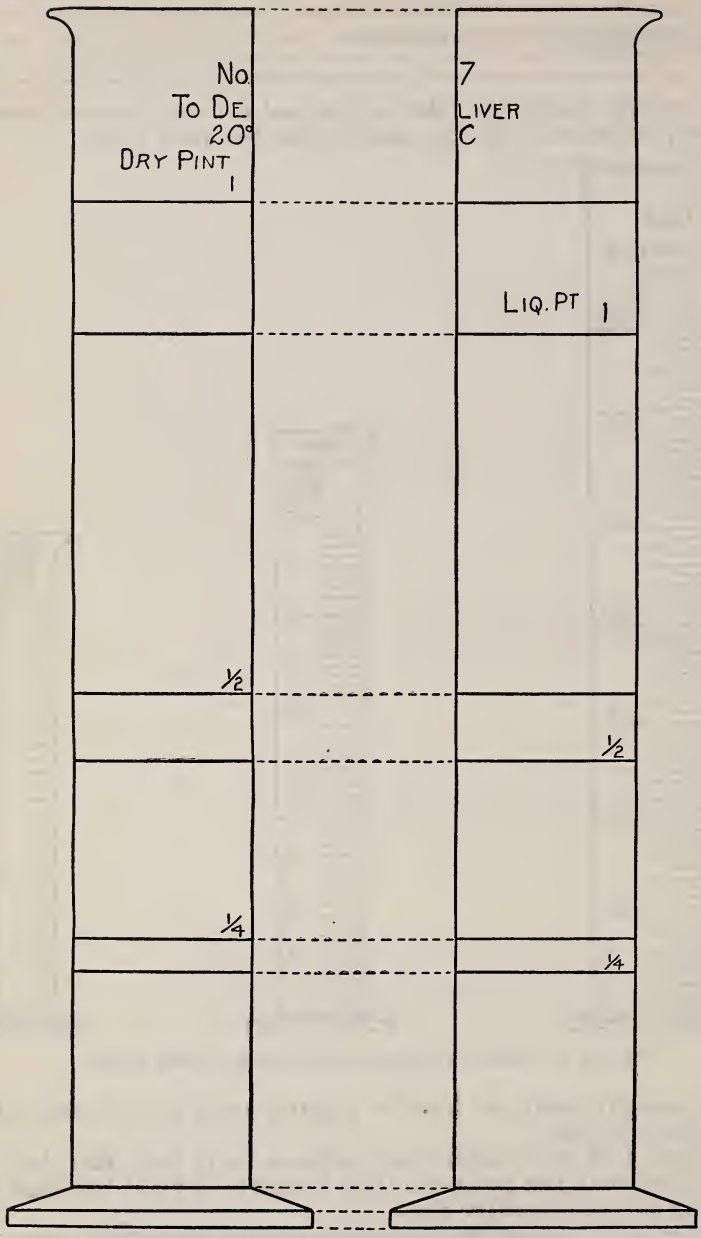

FIGURE 5.—*Special double-scale graduate, U. S. liquid pint and dry pint.*

(d) BURETTES AND MEASURING PIPETTES

Only those burettes emptying through a nozzle permanently attached at the bottom are accepted for test.

Side tubes, unless provided with stopcocks, are not permitted on burettes.

So-called Schellbach burettes—that is, those having a milk-glass background with a colored center line—will not be accepted for test on account of possible errors due to parallax.

The distance between the extreme graduations must not exceed 70 cm on burettes nor 35 cm on measuring pipettes.

The rate of outflow of burettes and measuring pipettes must be restricted by the size of the tip, and for any graduated interval the time of free outflow must be not more than 3 minutes nor less than the following for the respective lengths:

Length graduated	Time of outflow not less than—	Length graduated	Time of outflow not less than—
cm	*sec*	*cm*	*sec*
15	30	45	80
20	35	50	90
25	40	55	105
30	50	60	120
35	60	65	140
40	70	70	160

The upper end of any measuring pipette must be not less than 10 cm from the uppermost mark and the lower end not less than 4 cm from the lowest mark.

On 50-ml and 100-ml burettes the highest graduation mark should be not less than 4 cm nor more than 10 cm from the upper end of the burette. On burettes having a capacity of 25 ml or less this distance should be not less than 3 cm nor more than 6 cm.

(e) BURETTE AND PIPETTE TIPS

Burette and pipette tips should be made with a gradual taper of from 2 cm to 3 cm, the taper at the extreme end being slight.

A sudden contraction at the orifice is not permitted, and the end of the tip must be ground true, with a smooth plane surface, and finished with a polish or semipolish.

In order to facilitate the removal of drops and to avoid splashing when the instrument is vertical, the tip may be bent slightly.

Approved forms of tips for burettes, measuring pipettes, and transfer pipettes are shown in figure 6.

4. SPECIAL APPARATUS

(a) GILES FLASKS

The permissible error in the volume at the first mark shall be the tolerance allowed for a flask of that capacity. The permissible error in the volume at the second mark shall be the tolerance at the first mark plus the tolerance for a flask of capacity equal to the difference between the two marks, provided, however, that the error in the volume between the two marks shall not exceed the permissible error in the volume indicated by the first mark.

At the capacity mark the inside diameter of the neck shall be within the following limits:

Capacity	Inside diameter of neck		Capacity	Inside diameter of neck	
	Minimum	Maximum		Minimum	Maximum
ml	*mm*	*mm*	*ml*	*mm*	*mm*
25 to 27.5	6	9	500 to 550	12	18
50 to 55	6	11	1,000 to 1,100	14	20
100 to 110	8	13	2,000 to 2,200	18	25
200 to 220	9	15			

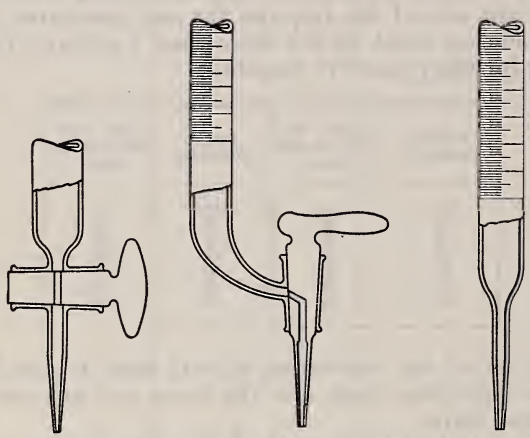

FIGURE 6.—*Types of burette and pipette tips.*

The neck shall be cylindrical on each side of every graduation mark for at least the following distances:

Capacity	Above upper graduation mark	Between upper graduation mark and bulb	Between lower graduation mark and bulb	Below lower graduation mark
ml	*cm*	*cm*	*cm*	*cm*
25 to 27.5	3	0.8	1	1
50 to 55	3	.8	1	1
100 to 110	3	.8	1	1
200 to 220	4	.8	1.5	2
500 to 550	4	1.0	1.5	2
1,000 to 1,100	5	1.0	1.5	2
2,000 to 2,200	5	1.0	1.5	2

On account of the bulb in the neck of a Giles flask it is more unstable or top-heavy than a flask of the ordinary type. For that reason it has been thought advisable to allow a somewhat shorter minimum length for the cylindrical portion of the neck, on each side of the graduation mark, than is allowed on ordinary flasks. In other respects the same general specifications apply to the Giles flasks as to other volumetric apparatus.

(b) SPECIFIC-GRAVITY FLASKS

MATERIAL AND ANNEALING.—The material from which the flasks are made shall be glass of the best quality, transparent, and free from striæ. It shall adequately resist chemical action and have small thermal hysteresis. The flasks shall be thoroughly annealed at 400° C and allowed to cool slowly for 24 hours, before being graduated. They shall be of sufficient thickness to insure reasonable resistance to breakage.

DESIGN.—The cross section of the flask shall be circular, and the shape and dimensions shall conform to the diagram shown in figure 7. This design is intended to insure complete drainage of the flask on emptying and stability of standing on a level surface, as well as accuracy and precision of reading. The neck of the flask shall be cylindrical for at least 1 cm above and below every graduation mark. There shall be a space of at least 1 cm between the highest graduation mark and the lowest point of the grinding for the glass stopper.

CAPACITY.—The flask should contain approximately 250 ml when filled to the zero graduation mark.

GRADUATIONS.—The neck shall be graduated from 0 to 1 ml and from 18 to 24 ml into 0.1-ml divisions. There shall be two 0.1-ml graduations below the 0 and two above the 1-ml graduation. The graduations shall be of uniform width, finely but distinctly etched, and shall be perpendicular to the axis of the flask. The 0.1-ml graduations shall be at least 1 mm apart. This will require an internal diameter of the neck not greater than 11.3 mm. The 1-ml graduations shall extend completely around the neck of the flask and shall be numbered to indicate the capacity. The 0.1-ml graduations shall extend at least halfway around the neck and the 0.5-ml graduations shall have a length about midway between the other two. The graduation marks shall have no evident irregularities of spacing.

STANDARD TEMPERATURE.—The flasks shall be standard at 20° C. The indicated specific gravities will then be at 20° referred to water at 4° as unity—that is, density at 20° in grams per milliliter.

INSCRIPTIONS.—Each flask shall bear a permanent identification number and the stopper shall bear the same number. The standard temperature shall be indicated and the unit of capacity shall be shown by the letters "ml" placed above the highest graduation mark.

TOLERANCE.—The error of any indicated capacity shall be not greater than 0.05 ml.

INTERPRETATION OF THE SPECIFICATION.—The foregoing specification is intended to represent the most desirable form of specific-gravity flask for use in testing cements. Variations of a few millimeters in such dimensions as total height of flask, diameter of base, etc., are to be expected and will not be considered sufficient cause for rejection. The requirements in regard to tolerance, inscriptions, length, spacing, and uniformity of graduations will, however, be rigidly enforced.

(c) SUGAR-TESTING FLASKS (BATES)

The flask shall have a height of 130 mm, and the neck shall be 70 mm in length; a tolerance of ± 5 mm is allowed for each. The internal diameter shall be not less than 11.5 mm and not more than

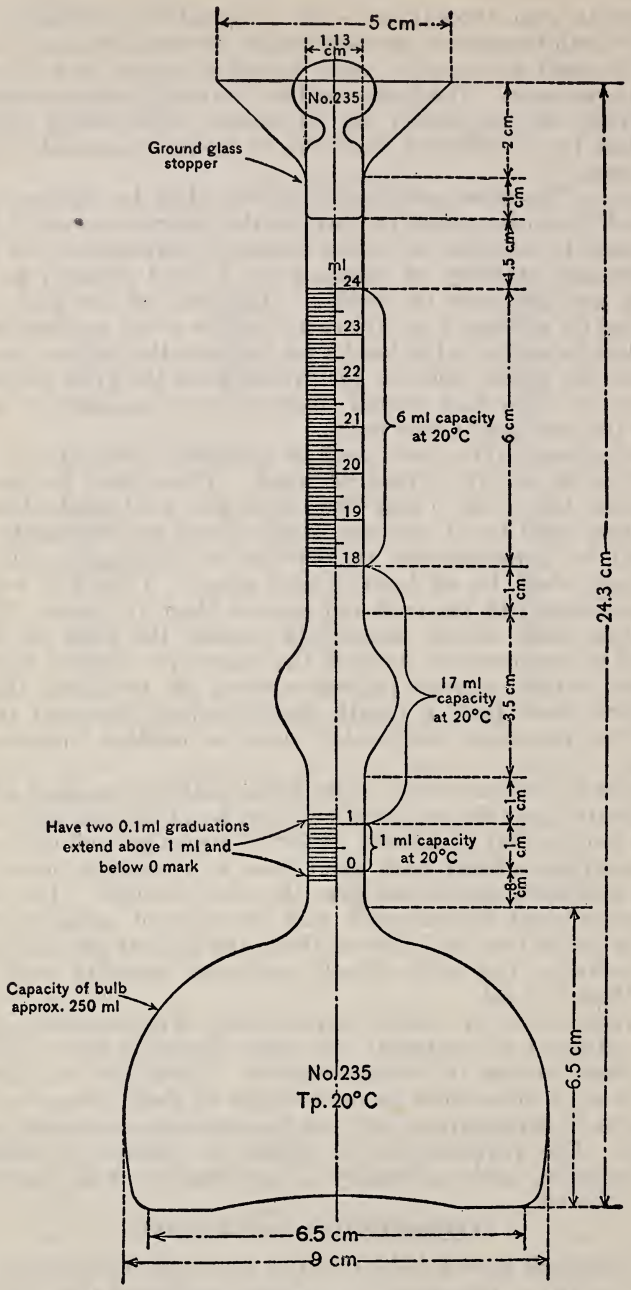

FIGURE 7.—*Specific-gravity flask.*

12.5 mm. The upper end of the neck shall be flared, and the graduation mark shall be not less than 30 mm from the upper end and 15 mm from the lower end of the neck. The flask shall be standardized to contain 100 ml at 20° C.

(d) BABCOCK TEST BOTTLES

The following specifications for standard Babcock glassware were proposed and adopted at a meeting held in Washington, D. C., on March 28, 1911, by a committee representing the Dairy Division of the United States Department of Agriculture, the Official Dairy Instructors' Association, the National Bureau of Standards, and the manufacturers of Babcock glassware. Slight revisions were made in 1923, with the addition of the 50-percent, 18-gram, long-neck (9-inch) cream-test bottle. These specifications have been adopted by the Official Dairy Instructors' Association and by the dairy departments of several States, and are now very generally employed by manufacturers and users of Babcock glassware.

SPECIFICATIONS.—The standard Babcock test bottles for milk and cream shall be the following:

(1) 8–percent, 18–gram, 6-inch milk-test bottle.
(2) 50-percent, 9-gram, short-neck (6-inch) cream-test bottle.
(3) 50-percent, 9-gram, long-neck (9-inch) cream-test bottle.
(4) 50-percent, 18-gram, long-neck (9-inch) cream-test bottle.

(1) *8-percent, 18-gram, 6-inch milk-test bottle.*—Graduation: The total percent graduation shall be 8. The graduated portion of the neck shall have a length of not less than 63.5 mm (2.5 inches [3]). The graduation shall represent 1 percent, 0.5 percent, and 0.1 percent. The 0.1-percent graduations shall be not less than 3 mm in length; the 0.5-percent graduations shall be 1 mm longer than the 0.1-percent graduations, projecting 1 mm to the left; the 1-percent graduations shall extend halfway around the neck to the right, projecting 2 mm to the left of the 0.1-percent graduations. Each percent graduation shall be numbered, the number being placed on the left of the scale. The maximum error of the total graduation or any part thereof shall not exceed the volume of the smallest unit of the graduation.

Neck: The neck shall be cylindrical for at least 5 mm below the lowest and above the highest graduation marks. The top of the neck shall be flared to a diameter of not less than 10 mm.

Bulb: The capacity of the bulb up to the junction of the neck shall be not less than 45 ml. The shape of the bulb may be either cylindrical or conical, with the smallest diameter at the bottom. If cylindrical, the outside diameter shall be between 34 and 36 mm; if conical, the outside diameter of the base shall be between 31 and 33 mm and the maximum diameter between 35 and 37 mm.

The charge of the bottle shall be 18 grams.

The total height of the bottle shall be between 150 and 165 mm (5⅞ and 6½ inches).

Each bottle shall bear a permanent identification number.

(2) *50-percent, 9-gram, short-neck (6-inch) cream-test bottle.*—Graduation: The total percent graduation shall be 50. The graduated portion of the neck shall have a length of not less than 63.5 mm (2.5 inches). The graduations shall represent 5 percent, 1 percent, and 0.5 percent. The 0.5-percent graduations shall be at least 3 mm in length;

[3] The U. S. customary equivalents here given are only approximate.

the 1-percent graduations shall be 2 mm longer than the 0.5-percent graduations, projecting 2 mm to the left; the 5-percent graduations shall extend halfway around the neck to the right and project 4 mm to the left of the 0.5-percent graduations. Each 5-percent graduation shall be numbered, the number being placed on the left of the scale. The maximum error of the total graduation or any part thereof shall not exceed the volume of the smallest unit of the graduation.

Neck: (Same as standard milk-test bottle.) The neck shall be cylindrical for at least 5 mm below the lowest and above the highest graduation marks. The top of the neck shall be flared to a diameter of not less than 10 mm.

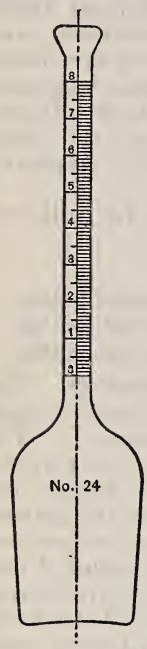

FIGURE 8.—*Milk-test bottle.*

Bulb: (Same as standard milk-test bottle.) The capacity of the bulb up to the junction of the neck shall be not less than 45 ml. The bulb may be either cylindrical or conical, with the smallest diameter at the bottom. If cylindrical, the outside diameter shall be between 34 and 36 mm; if conical, the outside diameter of the base shall be between 31 and 33 mm and the maximum diameter between 35 and 37 mm.

The charge of the bottle shall be 9 grams. The bottle shall bear on top of the neck above the graduations in plainly legible characters, a mark denoting the weight of the charge to be used (9 grams).

The total height of the bottle shall be between 150 and 165 mm (5⅞ and 6½ inches). (Same as standard milk-test bottles.)

Each bottle shall bear a permanent identification number.

(3) *50-percent, 9-gram, long-neck (9-inch) cream-test bottle.*—The same specifications in every detail as given for the 50-percent, 9-gram, 6-inch cream-test bottle shall apply to the 9-inch bottle, with the exception, however, that the total height of this bottle shall be between 210 and 229 mm (8¼ and 9 inches), and the graduated portion of the neck shall have a length of not less than 120 mm.

(4) *50-percent, 18-gram, long-neck (9-inch) cream-test bottle.*—The same specifications in every detail as given for the 50-percent, 9-gram, 9-inch cream-test bottle shall apply, except that the charge shall be 18 grams. The bottle shall bear on top of the neck above the graduations in plainly legible characters a mark denoting the weight of the charge to be used (18 grams).

The standard Babcock pipette

Total length of pipette not more than	[4] 330 mm
Outside diameter of suction tube	6 to 8 mm
Length of suction tube	125 to 135 mm
Outside diameter of delivery tube	4.5 to 5.5 mm
Length of delivery tube	100 to 120 mm
Distance of graduation mark above bulb	15 to 45 mm
Tolerance	0.05 ml

Nozzle straight.
To contain 17.6 ml of water at 20° C.
Delivery in 5 to 8 seconds.

[4] 330 mm = 13 inches, nearly.

Skim-milk-test bottles.—The committee did not adopt a standard skim-milk-test bottle, for the reason that experiments have shown that it can give only approximate results.

Babcock test bottles will be calibrated on the basis that on an 18-gram bottle each 1-percent interval has a capacity of 0.2 ml at 20° C, and that on a 9-gram bottle each 1-percent interval has a capacity of 0.1 ml at 20° C. The bottles indicate the percentages (by weight) of fat in 18 and 9 grams, respectively, of milk or cream, the fat being assumed to have a specific gravity of 0.9.

In using the test bottle the percentage of fat is read off at relatively high temperatures (40° to 60° C), but the error resulting from the increase in volume of the test bottle between 20° C and the temperature at which the readings are made may be disregarded, as in no case does it amount to more than one-tenth of the error allowed in the graduation of the bottle.

Unless otherwise requested, the capacity of each test bottle will be determined at two points; and if found correct within the limits allowed, the bottle will be stamped with the official precision stamp of the Bureau.

(e) DILUTION PIPETTES (HAEMACYTOMETERS)

The pipettes should be of good-quality glass, free from bubbles and streaks. Tubing with milk-glass backing is permissible. The capillary tube should be of uniform internal diameter. The bulb or mixing chamber should be provided with a suitable bead or other movable object to aid in mixing the blood and diluting fluid. The bulb and movable object should be so shaped that the filling and mixing can be accomplished without the entrapping of air bubbles in the mixing chamber. The capacity of the bulb is usually about 0.8 to 1.1 ml for the red pipette, and 0.2 to 0.4 ml for the white pipette.

The pipette should be so graduated as to give dilution ratios of 1 to 10, or 1 to 100, and may be further graduated to give ratios of 0.1, 0.2, 0.5, etc. to 10, and to 100; that is, the interval 0 to 1 may be subdivided to 0.1 or 0.5. The subdivisions, when present, should be uniformly spaced along the capillary tube. The graduations at 0.5, 1.0, 11, and 101, should be numbered.

The errors in the principal intervals of the pipette shall not exceed the following percentages: in a pipette having a nominal dilution ratio of 1 to 10, the interval 1 to 11 shall not differ from 10 times the interval 0 to 1 by more than 3.5 percent of its volume, and in the case of a pipette having a nominal dilution ratio of 1 to 100, the interval 1 to 101 shall not differ from 100 times the interval 0 to 1 by more than 5 percent of its volume.

5. TOLERANCES

(a) FLASKS

Capacity (in milliliters) less than and including—	Limit of error		Capacity (in milliliters) less than and including—	Limit of error	
	If to contain	If to deliver		If to contain	If to deliver
	ml	*ml*		*ml*	*ml*
25	0.03	0.05	1,000	0.30	0.50
50	.05	.10	2,000	.50	1.00
100	.08	.15	3,000	.75	1.50
200	.10	.20	4,000	1.00	2.0
300	.12	.25	5,000	1.2	2.4
500	.15	.30	6,000	1.5	3.0

(b) TRANSFER PIPETTES

Capacity (in milliliters) less than and including—	Limit of error	Capacity (in milliliters) less than and including—	Limit of error
	ml		*ml*
2	0.006	50	0.05
5	.01	100	.08
10	.02	200	.10
30	.03		

(c) BURETTES AND MEASURING PIPETTES

Capacity (in milliliters) of total graduated portion less than and including—	Limit of error of total or partial capacity		Capacity (in milliliters) of total graduated portion less than and including—	Limit of error of total or partial capacity	
	Burettes	Measuring pipettes		Burettes	Measuring pipettes
	ml	*ml*[1]		*ml*	*ml*
2		0.01	30	0.03	0.05
5	0.01	.02	50	.05	.08
10	.02	.03	100	.10	.15

(d) CYLINDERS

Tolerance for graduates of various diameters

[Metric units]

Diameter	Tolerance		Diameter	Tolerance		Diameter	Tolerance	
	To contain	To deliver		To contain	To deliver		To contain	To deliver
mm	*ml*	*ml*	*mm*	*ml*	*ml*	*mm*	*ml*	*ml*
10	0.04	0.05	41	0.65	0.85	72	2.7	3.4
11	.05	.06	42	.70	.90	73	2.8	3.5
12	.06	.07	43	.75	.95	74	2.9	3.6
13	.07	.08	44	.80	1.00	75	3.0	3.7
14	.08	.10	45	.85	1.05	76	3.1	3.9
15	.09	.11	46	.90	1.10	77	3.2	4.0
16	.10	.13	47	.95	1.15	78	3.3	4.1
17	.11	.14	48	1.00	1.20	79	3.4	4.3
18	.13	.16	49	1.05	1.30	80	3.5	4.4
19	.14	.18	50	1.1	1.3	81	3.6	4.5
20	.16	.20	51	1.1	1.4	82	3.7	4.6
21	.18	.22	52	1.2	1.5	83	3.8	4.7
22	.20	.24	53	1.2	1.6	84	3.9	4.8
23	.20	.26	54	1.3	1.6	85	4.0	5.0
24	.22	.28	55	1.4	1.7	86	4.1	5.1
25	.24	.30	56	1.4	1.8	87	4.2	5.2
26	.25	.35	57	1.5	1.9	88	4.3	5.3
27	.30	.35	58	1.6	1.9	89	4.4	5.4
28	.30	.40	59	1.6	2.0	90	4.5	5.0
29	.35	.40	60	1.7	2.1	91	4.6	5.7
30	.35	.45	61	1.8	2.2	92	4.7	5.8
31	.40	.45	62	1.8	2.3	93	4.8	5.9
32	.40	.50	63	1.9	2.4	94	4.9	6.1
33	.45	.55	64	2.0	2.5	95	5.0	6.2
34	.45	.55	65	2.1	2.6	96	5.1	6.3
35	.50	.60	66	2.2	2.7	97	5.2	6.5
36	.50	.65	67	2.2	2.8	98	5.3	6.6
37	.55	.65	68	2.3	2.9	99	5.4	6.7
38	.55	.70	69	2.4	3.0	100	5.5	6.9
39	.60	.75	70	2.5	3.1			
40	.65	.80	71	2.6	3.2			

(d) CYLINDERS—Continued

Tolerance for graduates of various diameters

[Customary units]

Diameter	Tolerance	
	To contain	To deliver
Inches	*Minims*	*Minims*
3/8	0.6	0.7
7/16	0.8	1.0
1/2	1.0	1.3
9/16	1.3	1.7
5/8	1.6	2.0
11/16	2.0	2.5
3/4	2.5	3.0
13/16	3.0	3.5
7/8	3.0	4.0
15/16	3.5	4.5
1	4	5
1 1/16	5	6
1 1/8	5	7
1 3/16	6	7
1 1/4	7	8
1 5/16	7	9
1 3/8	8	10
1 7/16	9	11
1 1/2	9	12
1 9/16	10	13
1 5/8	11	14
1 11/16	12	15
1 3/4	13	17
1 13/16	15	18
1 7/8	16	20
1 15/16	17	21

Diameter	Tolerance	
	To contain	To deliver
Inches	*fl dr min*	*fl dr min*
2	19	23
2 1/16	20	25
2 1/8	22	27
2 3/16	23	29
2 1/4	25	31
2 5/16	27	33
2 3/8	28	36
2 7/16	30	38
2 1/2	32	40
2 9/16	34	43
2 5/8	37	46
2 11/16	39	49
2 3/4	41	52
2 13/16	44	55
2 7/8	46	58
2 15/16	49	1 1
3	51	1 4
3 1/16	54	1 8
3 1/8	57	1 11
3 3/16	59	1 14
3 1/4	1 2	1 17
3 5/16	1 4	1 20
3 3/8	1 7	1 23
3 7/16	1 9	1 26
3 1/2	1 12	1 30
3 9/16	1 14	1 33
3 5/8	1 17	1 36
3 11/16	1 20	1 39
3 3/4	1 22	1 43
3 13/16	1 25	1 46
3 7/8	1 28	1 50
3 15/16	1 31	1 53
4	1 34	1 57

Maximum diameter of cylindrical graduates having the inside diameter equal to one-fifth the graduated length

Metric units			Customary units		
Capacity	Maximum diameter	Tolerance: to contain	Capacity	Maximum diameter	Tolerance: to contain
ml	*mm*	*ml*	*fl oz*	*in.*	*min*
5	11	0.05	1	3/4	2.5
10	14	.08	2	1	4
25	19	.14	4	1 1/4	7
50	23	.20	8	1 9/16	10
100	29	.35	16	1 15/16	17
250	40	.65	32	2 7/16	30
500	50	1.1	*cu in.*		*cu in.*
1,000	63	1.9	3	1 5/16	0.013
2,000	80	3.5	10	1 3/8	.03
			35	2 1/16	.08
			dry pt		
			1	2 1/16	.08

(c) DELIVERY TIME

The actual delivery time of any instrument must be within the limits prescribed in the specifications, and the error in the marked delivery time must not exceed the following:

Delivery time (in seconds) less than and including—	Limit of error in marked delivery time	Delivery time (in seconds) less than and including—	Limit of error in marked delivery time
	sec		*sec*
15	3	50	8
20	4	100	15
30	6	200	20

II. SPECIAL RULES FOR MANIPULATION

These rules indicate the essential points in the manipulation of volumetric apparatus which must be observed in order that the conditions necessary to obtain accurate measurements may be reproduced.

1. TEST LIQUID

Apparatus will be tested with water, and the capacity determined will therefore be the volume of water contained or delivered by an instrument at its standard temperature.

2. METHOD OF READING

In all apparatus where the volume is limited by a meniscus, the reading or setting is made on the lowest point of the meniscus. In order that the lowest point may be observed, it is necessary to place a shade of some dark material immediately below the meniscus, which renders the profile of the meniscus dark and clearly visible against a light background. A convenient device for this purpose is a collar-shaped section of thick black rubber tubing, cut open at one side and of such size as to clasp the tube firmly.

3. CLEANLINESS OF APPARATUS

Apparatus must be sufficiently clean to permit uniform wetting of the surface.

4. FLASKS AND CYLINDERS

In filling flasks, the entire interior of the vessel will be wetted; in the case of cylinders, the liquid is allowed to flow down one side only, but the entire wall is wetted for about 2 cm above the meniscus. A drainage time of about 2 minutes and 4 minutes, respectively, is allowed before completing the setting.

Flasks and cylinders when used to deliver should be emptied by gradually inclining them, avoiding, as much as possible, agitation of the contents and rewetting of the walls. Allow half a minute for emptying. When the continuous outflow has ceased, the vessel should be nearly vertical and should be held in this position for another half minute. The adhering drop should be removed by contact with the wet surface of the receiving vessel.

5. PIPETTES AND BURETTES

In filling pipettes and burettes excess liquid adhering to the tip should be removed when completing the filling.

In emptying burettes they should be held in a vertical position, and after the continuous unrestricted outflow ceases, the tip should be touched with the wet surface of the receiving vessel to complete the emptying. In the case of transfer pipettes they should be held in a vertical position and the outflow should be unrestricted until the surface of the water reaches the upper end of the delivery tube; the tip should then be touched to the wet surface of the receiving vessel and kept in contact with it until the emptying is complete.

The water remaining in the tip should not be blown out.

Stopcocks should be completely open during delivery.

Burettes and pipettes should be filled to about 2 cm above the zero, and the setting to the zero mark made by slowly emptying from this point.

While under normal usage the measurements ordinarily are from the zero mark, other initial points may be used on burettes of standard form without serious error.

For the convenience of those who may wish to calibrate their own volumetric apparatus a brief description of the method to be employed is here given.

In testing burettes, measuring pipettes, and transfer pipettes, the capacity of any interval may be determined by weighing the water delivered by the interval in question. The water is delivered into a weighing flask of convenient size provided with a stopper. The temperature of the water is observed either immediately before or immediately after delivery from the apparatus. A convenient method of observing the temperature is to have the weighing flask provided with a rubber stopper in which a thermometer is securely held, with its bulb near the bottom of the flask. If the thermometer is read immediately after the water is delivered into the flask, the observed temperature will be very close to that of the water while in the apparatus under test.

By means of tables 40 to 52, Circular No. 19, the capacity of the apparatus is determined from the weight of the water contained or delivered by it. For example, if it is desired to test the total interval of a 50-ml burette, the procedure is as follows: The burette is first carefully cleaned, and then filled with distilled water to about 2 cm above the zero mark. The water surface is set accurately on the zero by delivering into any convenient vessel the excess water above the mark. The tip of the burette is stroked off with filter paper to remove any excess water from the tip, and the water in the interval under test is then delivered into a weighing flask of convenient size fitted with a rubber stopper and thermometer.

In making the weighings it is both convenient and accurate to use the method of substitution. By this method a constant tare is kept on one pan of the balance, while on the other pan is placed the object to be weighed and with it sufficient weights to secure equilibrium. In testing volumetric apparatus the receiving flask is first weighed empty and then again after having delivered into it the water from the interval under test. The difference between the two weights is the weight of the water delivered.

Suppose, for example, that with a certain tare on the right-hand pan and the empty flask on the left a load of 151.276 grams is required in addition to the flask to restore equilibrium, and that after the water from the 50-ml interval of the burette under test is delivered into the flask only 101.448 grams are required, and that the water is at a temperature of 23.4° C. The weight of the water added is then 151.276−101.448=49.828 grams. From table 48, Circular No. 19, it is seen that to determine the capacity of a 50-ml vessel at 20° from the weight of water delivered at 23.4° C, 0.174 must be added to the weight; that is, the capacity of the 50-ml interval of the burette under test at 20° C is 49.828+0.174=50.002 ml.

The correction to be applied to the weight of water delivered by any other interval to obtain its capacity at 20° C is obtained in the same way. For example, to the weight of water delivered by the 10-ml interval at 18° C must be added one-tenth of the amount shown in table 43 for 100 ml; for a 20-ml interval, one-tenth of that shown in table 41.

In testing a flask or cylinder it is only necessary, after cleaning and drying the apparatus, to weigh it empty, fill it accurately to the graduation mark, and again weigh. The procedure to find the capacity at 20° from the weight of the water contained at a known temperature is the same as outlined above for the burette.

In case flasks are to be tested in large numbers, a volumetric method may be used to advantage. This Bureau uses a series of Volumetric Standards, each having a capacity slightly less than that of the flask it is intended to test. The water delivered from the appropriate standard fills the flask nearly to the graduation mark. The filling is then completed by means of a finely graduated burette. The capacity of the flask is then found from the known volume delivered by the standard and the additional volume delivered by the burette.

The flask standard and the burette are themselves calibrated as outlined above by weighing the water delivered.

III. TESTS PERFORMED BY THE BUREAU

1. NATURE OF TESTS

Apparatus submitted for test is first examined as to its conformity with the specifications concerning design and marks, including test of outflow time where this is limited.

Apparatus having subdivisions is examined as to the apparent regularity of spacing.

If the apparatus complies with the specifications in other respects, a test is made of its capacity.

This test may be either to ascertain whether the capacity is correct within the prescribed limits of error or to determine the correction for use in precise measurements.

2. PRECISION STAMP

If the results of the examination and the test of volumetric flasks, specific-gravity flasks, cylinders, measuring pipettes, transfer pipettes,

dilution pipettes, and Babcock pipettes and test bottles indicate a satisfactory conformity to the specifications, the official precision stamp, consisting of the letters "NBS" and the year date, surrounded by a circle, is etched as shown below:

3. CERTIFICATES OF CAPACITY

Burettes will be tested for at least five intervals, and if found to conform to the specified requirements will, in addition to the precision stamp, be assigned a National Bureau of Standards certificate number as shown below:

NBS No. 1763

1941

A certificate will be furnished giving the volumes delivered by the intervals tested.

Only in special cases will certificates of capacity be issued for volumetric and specific-gravity flasks, cylinders, measuring pipettes, transfer pipettes, dilution pipettes, and Babcock pipettes and test-bottles. When the measurements depending upon the use of the volumetric glassware are required to be so precise that a statement to the effect that the apparatus is within the tolerances prescribed in this Circular does not give sufficiently exact information, certificates may be issued. The request for certificates, when required, should be made at the time the apparatus is submitted for test.

4. SPECIAL TESTS

The Bureau will gladly cooperate with scientific investigators, manufacturers of apparatus, and others who need higher precision than is provided in the regular tests, as far as the regular work of the Bureau will permit. Tests not at present provided for may be undertaken if they are important and the facilities and time are available. Approved tests not provided for in the regular schedules will be considered special, and special fees will be charged for them. The test should be arranged for by correspondence before shipment of the apparatus. The application should state fully the purpose for which the apparatus has been used or is to be used, the need for the test, and the precision desired. The special fee charged will depend chiefly upon the time consumed and the amount of alteration required in the regular testing apparatus. An estimate of the fee will be given when possible.

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

IV. DIRECTIONS FOR SUBMITTING APPARATUS FOR TEST

1. APPLICATION FOR TEST

The request for test should be made in writing and should include a complete list of the apparatus and a statement of the nature of the test desired. Representatives of National or State institutions entitled to tests free of charge must make application in writing for each test in order to avail themselves of the privilege. Unless certificates are requested, volumetric and specific-gravity flasks, cylinders, measuring pipettes, transfer pipettes, dilution pipettes, and Babcock pipettes and test bottles are examined and tested to determine whether they are in conformity with specified requirements, and if satisfactory are given the precision stamp.

Unless otherwise requested, burettes will be examined and the capacity of five intervals tested. If in satisfactory conformity with the requirements, the results of the test are certified. If more than five intervals are to be tested, the request must so state.

Patrons should always examine apparatus carefully before submitting it for test to ascertain if it complies with the specifications. Delay and cost of transportation on apparatus not entitled to verification will thus be avoided.

The Bureau does not sell volumetric apparatus. It may be purchased from manufacturers, importers, or jobbers, and submitted to the Bureau for test.

Purchasers of apparatus to be submitted to the Bureau for test should so specify to the dealer in order to avoid unnecessary delays and misunderstandings.

2. IDENTIFICATION MARKS

The instruments and the packages in which they are shipped should both be plainly marked to facilitate identification, preferably with the name of the manufacturer or shipper, and a special reference number should be given to each article, which should be referred to in the correspondence concerning the test. After receipt at the Bureau, the National Bureau of Standards test number should also be used.

3. SHIPPING DIRECTIONS

The apparatus should be securely packed in cases or packages which will not be broken in transportation and which may be used in returning them to the owner. The shipment in both directions is at the applicant's risk. It is recommended that shipment be made by express. Great care should be taken in packing. Clean, dry excelsior is a suitable packing material in most cases. Each instrument should also be wrapped in strong paper or other covering to prevent dust and excelsior from getting into it. The top of the shipping box should be put on with screws, as the jar due to nailing and the subsequent opening is liable to cause damage. The top of the box should have the return or forwarding address on the underside. Transportation charges are payable by the party requesting the test. The charges for shipment to the Bureau must be prepaid, and, unless otherwise arranged, articles will be returned or forwarded by express "collect."

4. BREAKAGE

A not inconsiderable number of pieces of glassware are received broken, either on account of improper packing or rough treatment in transportation, or both. Some are broken in return shipment. A small percentage is broken in the testing laboratory.

There is no legal way in which the Bureau can make reimbursement for breakages of this kind. It is therefore a matter of necessity, and not of choice, that the Bureau makes those who send apparatus for test assume all the risks involved. Damages to apparatus, even in cases where the Bureau would be pleased to assume them, can not be made good out of fees received for testing, since such fees are not expendable by the Bureau but are covered directly into the United States Treasury. Under the circumstances, all that the Bureau can do is to make every effort to reduce such breakage to the absolute minimum under the conditions under which the work has to be done.

5. ADDRESS

Articles should be addressed, "National Bureau of Standards, Washington, D. C."; delays incident to other forms of addresses will thus be avoided. Articles delivered personally or by messenger should be left at the shipping office of the Bureau, and should be accompanied by a written request for test.

6. REMITTANCES

Payment of test fee should be made promptly upon receipt of bill, as certificates or reports are not mailed until the fees due thereon have been paid.[5] Remittances may be made by money order or check drawn to the order of the "National Bureau of Standards."

Copies of "Test Fee Schedule: Volumetric Apparatus" may be obtained from the Bureau, upon request.

All communications should be addressed, "National Bureau of Standards, Washington, D. C."

WASHINGTON, August 1, 1941.

[5] In the case of apparatus submitted for an institution for which tests are made free of charge the bill for testing rejected apparatus and for supplying missing identification numbers may be rendered to the concern furnishing the apparatus.

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