Designation: E694 – 18

Standard Specification for Laboratory Glass Volumetric Apparatus[1]

This standard is issued under the fixed designation E694; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 This specification covers general requirements common to glass volumetric apparatus. Specific dimensions and tolerances for applicable instruments are given in other specifications as cited throughout this specification. Glass must conform to Specifications E438 and be calibrated in accordance with Practice E542.

1.1.1 *Class A*—Each instrument shall be marked with the letter *A* to signify compliance with applicable construction and accuracy requirements. Instruments may be marked with an identification marker (serial number) at the option of the manufacturer.

1.1.2 *Class B*—General purpose instruments are of the same basic design as Class A. However, volumetric tolerances for Class B instruments shall be within twice the specified range allowed for Class A unless otherwise specified.

1.2 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C188 Test Method for Density of Hydraulic Cement
E237 Specification for Laboratory Glass Microvolumetric Vessels (Volumetric Flasks and Centrifuge Tubes)
E287 Specification for Laboratory Glass Graduated Burets
E288 Specification for Laboratory Glass Volumetric Flasks
E438 Specification for Glasses in Laboratory Apparatus
E542 Practice for Calibration of Laboratory Volumetric Apparatus
E671 Specification for Maximum Permissible Thermal Residual Stress in Annealed Glass Laboratory Apparatus
E675 Specification for Interchangeable Taper-Ground Stopcocks And Stoppers
E676 Specification for Interchangeable Taper-Ground Joints
E788 Specification for Pipet, Blood Diluting
E911 Specification for Glass Stopcocks with Polytetrafluoroethylene (PTFE) Plugs
E969 Specification for Glass Volumetric (Transfer) Pipets
E1045 Specification for Pipet, Sahli Hemoglobin
E1272 Specification for Laboratory Glass Graduated Cylinders
E1878 Specification for Laboratory Glass Volumetric Flasks, Special Use

3. General Requirements

3.1 *Units of Volume*—The unit of volume shall be the cubic centimetre (cm^3) or, in special cases, the cubic decimetre (dm^3) or cubic millimetre (mm^3).

NOTE 1—The term millilitre (mL) is commonly used as a special name for the cubic centimetre (cm^3) and, similarly the litre for the cubic decimetre (dm^3) and the microlitre (μL) for the cubic millimetre (mm^3), in accordance with the International System of Units (SI).

3.2 *Standard Temperature*—The standard reference temperature, that is, the temperature at which the article of volumetric glassware is intended to contain or deliver its nominal volume (nominal capacity), shall be 20°C.

NOTE 2—When it is necessary in tropical countries to work at an ambient temperature considerably above 20°C, and it is not desired to use the standard reference temperature of 20°C, it is recommended that a temperature of 27°C be adopted.

3.3 *Material and Annealing*—Volumetric glassware shall be constructed of glass of suitable chemical and thermal properties. It shall be as free as possible from visible defects and shall conform to Specification E671.

3.4 *Limit of Error*—On an article having multiple graduation lines, the limit of volumetric error may occur at any graduation line unless otherwise specified. For example, on a 100-mL graduated cylinder having a limit of error of ±1.00 mL, the volume at 10 mL could range from 9.00 to 11.00 mL.

NOTE 3—The limit of volumetric error specified for any article designed for delivery shall not be less than four times the standard deviation

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

determined experimentally by an experienced operator from a series of at least twenty replicate determinations of delivered capacity on the same article, carried out strictly in accordance with the method specified for that article.

3.5 *Stability*—Vessels provided with a flat base shall stand firmly thereon without rocking when placed on a level surface and, unless specified otherwise, the axis of the graduated portion of the vessel should be vertical. Except for special cases, vessels shall not topple when placed empty and without a stopper on a surface inclined at an angle to the horizontal of 15° for sizes 25 cm^3or greater and 10° for vessels less than 25 cm^3. Vessels provided with a base that is not circular shall meet this requirement in all directions.

3.6 *Stoppers and Stopcocks:*

3.6.1 *Stoppers*—Glass stoppers should be ground so as to be interchangeable, in which case the ground portions shall be in accordance with Specification E675. Stoppers of a suitable inert plastics material may be permitted as an alternative to glass. In such cases, the glass socket into which the stopper fits shall be in accordance with Specification E675. All stoppers shall bear a proper size identification.

3.6.2 *Stopcocks*—Stopcocks and similar devices shall be designed to permit smooth and precise control of outflow and to prevent a rate of leakage greater than that allowed in the specification for the article and shall be in accordance with Specification E675. Stopcocks shall be made from glass or from suitable inert plastics material.

3.7 *Graduation Lines:*

3.7.1 Graduation lines shall be clean, permanent lines of uniform vertical thickness. This thickness shall be 0.2–0.6 mm for articles not having a scale. On articles having a scale, the specified thickness of the lines shall be 0.2–0.4 mm. All graduation lines shall lie in planes at right angles to the longitudinal axis of the graduated portion of the article. On articles provided with a flat base, the graduation lines shall therefore lie in planes parallel to the base.

3.7.2 In general, graduation lines should be confined to cylindrical portions of an article's cross section and should preferably be situated not less than 10 mm from any change in diameter. In special circumstances, preferably for Class B articles only, graduation lines may be provided on a parallel side portion of noncircular cross section or on a conical or tapered portion of the article.

3.7.3 On articles not having a scale, all graduation lines should extend completely around the circumference of the article, except that a gap, not exceeding 10 % of the circumference, may be permitted. In the case of an article that is restricted as to the normal direction of viewing in use, the gap should be at the right or left of the normal direction of view.

3.8 *Spacing of Graduation Lines*—There should be no evident irregularity spacing of graduation lines (except in special cases where the scale is on a conical or tapered portion of the article and a change of subdivision takes place). The minimum distance, *L*, between the centers of adjacent graduation lines shall be not less, in relation to diameter, than that calculated as follows:

$$L = (0.8 + 0.02D) \quad (1)$$

where *D* is the maximum permitted internal diameter of the tube in millimetres (see also Annex A1).

3.9 *Length of Graduation Lines* (see Fig. 1)—On articles of circular cross section having a scale, the length of the graduation lines shall be varied so as to be clearly distinguishable and shall be in accordance with the following provisions:

3.9.1 *Graduation Pattern I:*

3.9.1.1 The length of the short lines should be approximately, but not less than, 50 % of the circumference of the article.

3.9.1.2 The length of the medium lines should be approximately 65 % of the circumference of the article and should extend symmetrically at each end beyond the end of the short lines.

3.9.1.3 The long lines should extend completely around the circumference of the article, but a gap, not exceeding 10 % of the circumference, may be permitted (see 3.6).

3.9.2 *Graduation Pattern II:*

3.9.2.1 The length of the short lines should be not less than 10 % and not more than 20 % of the circumference of the article.

3.9.2.2 The length of the medium lines should be approximately 1.5 times the length of the short lines and should extend symmetrically at each end beyond the end of the short lines.

3.9.2.3 The long lines should extend completely around the circumference of the article, but a gap, not exceeding 10 % of the circumference, may be permitted (see 3.6).

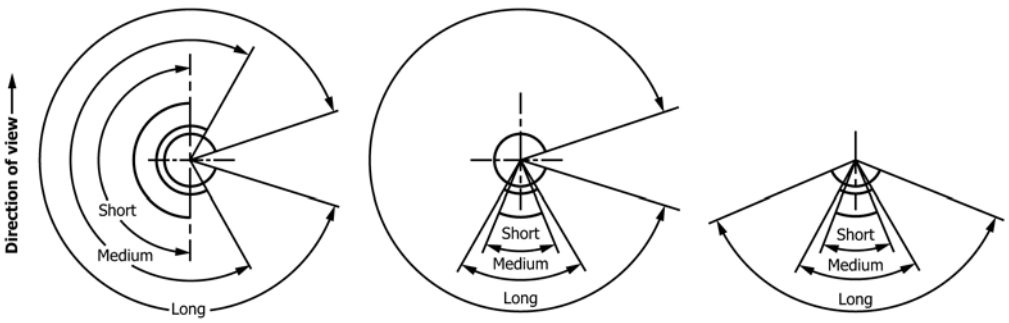

FIG. 1 Position of Graduation Lines

3.9.3 *Graduation Pattern III:*

3.9.3.1 The length of the short lines should not be less than 10 % and not more than 20 % of the circumference of the article.

3.9.3.2 The length of the medium lines should be approximately 1.5 times the length of the short lines and should extend symmetrically at each end beyond the ends of the short lines.

3.9.3.3 The length of the long lines should be not less than twice the length of the short lines and should extend symmetrically at each end beyond the ends of the short and medium lines.

3.9.4 In special cases where scales are required on noncircular cross section or conical or tapered portions of an article, the requirements of 3.8.1, 3.8.2, or 3.8.3 should be modified appropriately.

3.10 *Sequence of Graduation Lines* (see Fig. 2):

3.10.1 On articles in which the volume equivalent of the smallest scale division is millilitre (or a decimal multiple or submultiple thereof):

3.10.1.1 Every tenth graduation line is a long line;

3.10.1.2 There is a medium line midway between two consecutive long lines; and

3.10.1.3 There are four short lines between consecutive medium and long lines.

3.10.2 On articles in which the volume equivalent of the smallest scale division is 2 mL (or a decimal multiple or submultiple thereof):

3.10.2.1 Every fifth graduation line is a long line; and

3.10.2.2 There are four short lines between two consecutive long lines.

3.10.3 On articles in which the volume equivalent of the smallest scale division is 5 mL (or a decimal multiple or submultiple thereof):

3.10.3.1 Every tenth graduation line is a long line;

3.10.3.2 There are four medium lines equally spaced between two consecutive long lines; and

3.10.3.3 There is one short line between two consecutive medium lines or between consecutive medium and long lines.

3.11 *Position of Graduation Lines* (see Fig. 1):

3.11.1 On articles graduated according to Pattern I with vertical scales in accordance with 3.9.1, the ends of the short graduation lines shall lie on an imaginary vertical line down the center of the front of the article, the lines themselves extending preferably to the left when the article is viewed from the front in the position of normal use.

3.11.2 On articles graduated according to Pattern II or III, with vertical scales in accordance with 3.9.2 or 3.9.3, the midpoints of the short and medium graduation lines shall lie on an imaginary vertical line down the center of the front of the article, when the article is viewed from the front in the position of normal use.

3.12 Two scales are not permitted on the same piece of apparatus. For example, apparatus should not be graduated in both fluid ounces and millilitres (cubic centimetres). In the case of two units, one of which is an exact multiple of the other, such, for example, as drams and fluid ounces, there is no objective to having the 8-dr line, 16-dr line, etc., marked respectively, 1 fluid oz, 2 fluid oz, etc., provided that the two series of numbers are placed on opposite sides of the apparatus and the value of each subdivision is suitably indicated.

3.13 *Figuring of Graduation Lines:*

3.13.1 On articles with one graduation line, the number representing nominal capacity may be included with the other inscriptions and need not be adjacent to the graduation line.

3.13.2 On articles having two or three graduation lines, the numbers representing nominal capacity need not be adjacent to the lines to which they relate, if some other more suitable method of identification is used.

3.13.3 On articles having one principal graduation line and a small number of subsidiary lines, the number representing the principal capacity may be included with the other inscriptions as in 3.13.1 provided that the subsidiary graduation lines are suitably identified.

3.13.4 *On Articles Having a Scale:*

3.13.4.1 The scale shall be figured so as to enable the value corresponding to each graduation line to be identified readily;

3.13.4.2 The scale should have normally only one set of figures;

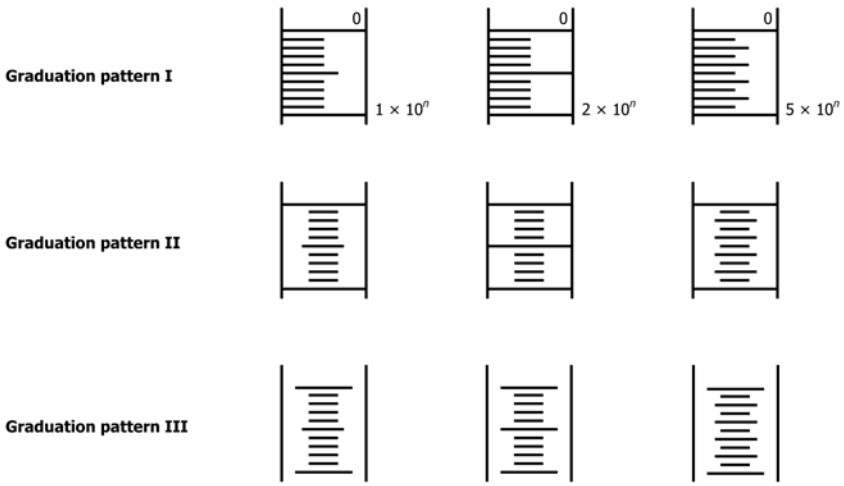

FIG. 2 Length and Sequence of Graduation Lines