

Standard Specification for Piston or Plunger Operated Volumetric Apparatus¹

This standard is issued under the fixed designation E1154; 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.

1. Scope

1.1 This specification covers requirements, operating conditions, and test methods for piston or plunger operated volumetric apparatus (POVA).

1.2 This specification includes specifications applicable for all types of POVA or those given by the manufacturer. The following precautionary caveat pertains only to the test method portion, Section 13, of this specification: *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E617 Specification for Laboratory Weights and Precision Mass Standards

E898 Test Method of Testing Top-Loading, Direct-Reading Laboratory Scales and Balances

2.2 *ISO Documents:*²

ISO 3534 Statistics—Vocabulary and Symbols

ISO 653 Long Solid-Stem Thermometers for Precision Use

ISO 655 Long Enclosed-Scale Thermometers for Precision Use

ISO 4787 Laboratory Glassware—Volumetric Glassware—Methods for Testing and Use

2.3 *Other Documents*³

OIML R 111-1 Weights of classes E₁, E₂, F₁, F₂, M₁, M₁₋₂, M₂, M₂₋₃ and M₃; Part 1: Metrological and technical requirements

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

¹ This specification is under the jurisdiction of ASTM Committee E41 on Laboratory Apparatus and is the direct responsibility of Subcommittee E41.06 on Laboratory Instruments and Equipment.

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² Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

³ Available from International Organization of Legal Metrology, 11 rue Turgot, 75009 Paris, France. www.oilm.org/en/

3.1.1 *accuracy*⁴—the accuracy of an instrument is the closeness of agreement between the nominal volume and the mean volume, obtained by applying the test procedure specified in Section 13 of this specification. It is quantified by the inaccuracy of the mean.

3.1.2 *dead volume*—the dead volume is that part of the total liquid volume, held in the operational part of the device, which is not delivered.

3.1.2.1 *Discussion*—The dead volume should not be confused with the dead space of an air displacement instrument.

3.1.3 *disposable*—those parts of an instrument that are intended to be used once only and then discarded. Disposable parts are generally intended for use in applications where sample carryover is intolerable.

3.1.4 *maximum error*—the maximum difference between the nominal volume and any single individual volume obtained by applying the test procedure specified in Section 13 of this Specification.

3.1.5 *maximum expectable error*—with more than 95 % probability, the maximum expectable error is calculated as follows:

$$\pm (1E_T + 2s) \quad (1)$$

where:

E_T = inaccuracy of the mean, and

s = standard deviation from the repeatability test in Section 13.

3.1.6 *nominal volume(s)*—the stated volume(s) for which performance is specified.

3.1.7 *piston or plunger operated volumetric apparatus (POVA)*—the volume of liquid to be measured with POVA is defined by one or more strokes of one or more pistons or plungers. POVA may be operated manually or mechanically (for example, electrically, pneumatically or by hydrostatic pressure).

3.1.7.1 *Discussion*—In the following text the word ‘piston’ means ‘piston or plunger.’

⁴ These definitions apply only in the cases where the distributions are Gaussian.

3.1.8 *precision*⁴—the closeness of agreement between the individual volumes obtained by applying the test procedure specified in this specification. It is quantified by the imprecision.

3.1.8.1 *Discussion*—The test procedure specified gives only a measure of the repeatability (see ISO 3534) under controlled conditions.

3.1.9 *reference temperature*—the temperature at which the instrument is designed to deliver its nominal volume(s).

3.1.9.1 *Discussion*—At that temperature the closest agreement between manufacturer's performance claims and test results may be expected.

3.1.10 *reference temperature range*—that temperature range for which the tolerances for accuracy are specified.

3.1.11 *reusable*—those parts of an instrument that are meant to be used more than once. As the reusability of some parts can rarely be quantified, any institution or individual who reuses a reusable part must see to its safety and effectiveness. Reusable parts are generally intended for use in applications where sample carryover is tolerable, or can be adequately prevented.

3.1.12 *sample carryover*—that portion of the sample that is retained in the instrument and that may affect subsequent samples.

3.1.13 *stated feature*—any feature claimed by the manufacturer.

3.1.14 *unit of volume*—the millilitre or the microlitre, that are accepted substitutes for the cubic centimetre or cubic millimetre.

3.1.14.1 *Discussion*—It is recommended that volumes should be specified in microlitres up to 999 μL , and in millilitres from 1 mL.

3.1.15 *working range*—that part (of the total range) for which manufacturer's performance specifications are given.

3.1.16 *working temperature range*—that range of temperatures for which manufacturer's performance specifications are given.

4. Classification

4.1 *Types of POVA*—Piston or plunger operated volumetric apparatus (POVA) are classified as follows:

4.1.1 *Pipette*—A measuring instrument for the transfer of a predetermined volume of liquid from one vessel to another. It is not connected to a reservoir.

4.1.2 *Dispenser*—A measuring instrument for delivering predetermined volumes of liquid from a reservoir. The reservoir may be integrated with the instrument or connected externally.

4.1.3 *Dilutor*—A measuring instrument for taking up different liquids (for example, sample and diluent) and delivering them in combination so as to comprise a predetermined ratio, or predetermined volumes, or both. The reservoir of diluent may be integrated with the instrument or connected externally.

4.1.4 *Displacement Buret*—A measuring instrument from which the volume delivered is determined by an external indicator. The volume delivered can then be read.

4.2 Types of Displacement:

4.2.1 Displacement with an air interface ("air displacement"). The delivered liquid is displaced by an air interface (indirect action), (see Figs. 1 and 2).

4.2.2 Displacement without an air interface ("positive displacement"). The delivered liquid is displaced either by a liquid interface (indirect action) or by actual contact with the piston (direct action), (see Fig. 3 and Fig. 4).

5. Performance Requirements

5.1 Performance Tolerances:

5.1.1 Performance tolerances specified for POVA are meant to include any thermal drift effect upon the accuracy and precision attributable to hand-transmitted heat during normal use. It is, therefore, important that the instrument being evaluated according to the referenced procedure not be preconditioned (warmed) by recent handling, nor isolated from normal handwarming during the test series (30 or 10 cycles).

5.1.2 Volumetric performance tolerances are not specified in this specification. The manufacturer shall specify the performance tolerances in terms of the accuracy of the mean ($\bar{E}_C$ %) and coefficient of variation (CV_C %). Values shall be given for the minimum and maximum volumes of the working range, as well as for any intermediate volumes in the series 1, 2, 5, 10

5.2 The reference temperature recommended for all POVA is 21.5°C, which is the mid-point of the reference temperature range, (see section 3.1.10). The use of another reference temperature must be stated by the manufacturer.

5.2.1 *Reference Temperature Range*—The reference temperature range for all POVA shall be 19 to 24°C, (see section 3.1.9 and section 3.1.10).

5.3 Removable Parts:

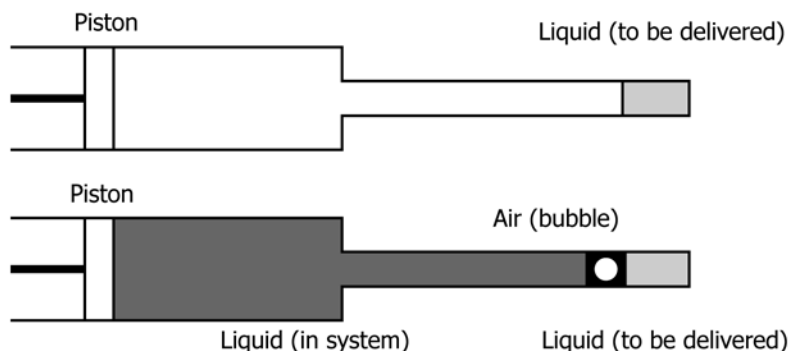


FIG. 1 Displacement With an Air Interface (Air Displacement)

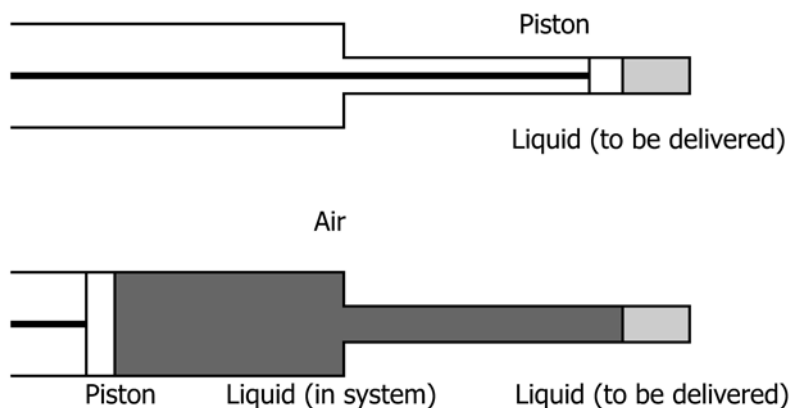


FIG. 2 Displacement Without an Air Interface (Positive Displacement)

PLUNGER POSITIONS

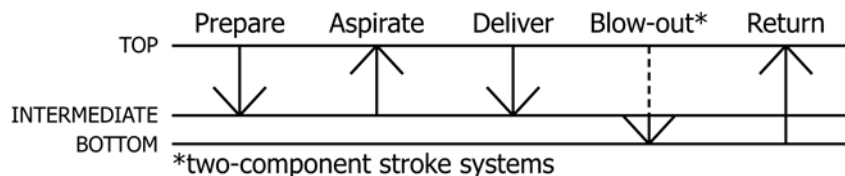


FIG. 3 Pipetter Mode of Operation (Forward Mode)

PLUNGER POSITIONS

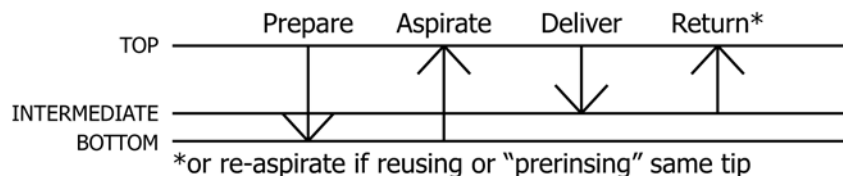


FIG. 4 Pipetter Mode of Operation (Reverse Mode)

5.3.1 The volumetric performance of POVA to be used with removable parts can depend to a large extent on the design, material, and workmanship of those parts. The test procedures described can give information only about the performance of the instruments together with the removable parts actually used.

5.3.2 *Single-Measurement Test*—The single-measurement test requires either 30 or 10 randomly selected removable parts, one for each sample of the series. This test evaluates the instrument's performance and component of imprecision due to the variation of these parts.

5.3.3 *Replicate-Delivery Test*—The replicate delivery test uses one removable part for the 30 or 10 sample series. This test evaluates the instrument's performance and the component of imprecision due to the reuse of this part.

5.4 *Durability*—Any claim by a manufacturer that an instrument is resistant to any defined conditions (for example, sterilization and chemical exposure) shall be understood in such a way that even long term or repeated exposure to those

conditions (as specified by the manufacturer) will not affect the rated performance of the instrument.

6. General Operating Conditions

6.1 *Relationship to Performance*—The specification of operating procedures is critical to the proper functioning of the instruments, and determines their ability to perform within specified tolerances. Changes in the operating mode can dramatically alter the results of analyses. Most instruments are calibrated for certain operating modes; another manner of use may result in a change in the accuracy or precision, or both.

6.2 *Delineation*—It is the manufacturer's responsibility to delineate the modes of operation in instruction manuals and to state for which of the modes the instrument is calibrated.

6.3 *Preparation*—The manufacturer shall provide instructions necessary for the preparation of the instrument for use in particular operating modes (for example, mounting of removable parts, method of volume adjustment, etc.).