Designation: E542 – 22

Standard Practice for Gravimetric Calibration of Laboratory Volumetric Instruments[1]

This standard is issued under the fixed designation E542; 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 practice covers procedures for use in the calibration of volumetric instruments that include glassware, plasticware, and laboratory standards that are in common use in chemical, analytical, clinical, and calibration laboratories. It is based on the gravimetric determination of the quantity of pure water, either contained or delivered at a calibration temperature, and the conversion of this value to a volume at a given reference temperature, normally 20 °C by means of suitable equations. Calibration using mercury is excluded. Calibration may be performed using alternative gravimetric methodology, if it is demonstrated and documented that the results obtained are equivalent to those obtained using the methodology described herein. Alternative reference temperatures and associated equations are provided.

1.2 This practice is intended to encompass volume capacity instruments between the limits of 0.1 cm^3 and 10 000 cm^3. Typical volumetric instruments falling within the purview of this practice are burettes graduated "to deliver," graduated cylinders, volumetric flasks, measuring and dilution pipettes, transfer and capacity pipettes such as those in Specification E694, specific gravity flasks such as those used in several ASTM standards, and metallic volumetric standards such as those used in legal metrology.

1.3 The procedures are not recommended for calibration of volumetric instruments with capacities below 0.1 cm^3, such as microglassware without incorporating evaporation corrections; evaporation methods and corrections are not provided. Capacities given in 1.2 are not intended to be maximum capacity limitations; volumes greater than 10 000 cm^3 may be calibrated with this procedure. Maximum capacity limitations are based on available equipment, standards, adequate quantities of pure water, and the ability to safely handle large volumetric instruments.

1.4 This standard may be used for the calibration of volumetric instruments made from materials of glass, plastic, various stable metals, or any other stable materials provided appropriate volumetric coefficients of expansions are available.

1.5 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.6 *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]

D1193 Specification for Reagent Water

E617 Specification for Laboratory Weights and Precision Mass Standards

E694 Specification for Laboratory Glass Volumetric Apparatus

E898 Practice for Calibration of Non-Automatic Weighing Instruments

2.2 *ISO Standards:*[3]

ISO 384 Laboratory Glass and Plastics Ware — Principles of Design and Construction of Volumetric Instruments

ISO 3696:1987 Water for Analytical Laboratory Use. Specification and Test Method

ISO 4787:2010 Laboratory Glassware – Volumetric Instruments – Methods for Testing of Capacity and for Use

ISO/IEC 17025:2017 General Requirements for the Competence of Testing and Calibration Laboratories

[1] This practice is under the jurisdiction of ASTM Committee E41 on Laboratory Apparatus and is the direct responsibility of Subcommittee E41.01 on Laboratory Ware and Supplies.

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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.

[3] Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, https://www.iso.org.

2.3 *NIST Standards:*[4]

GLP 10 Good Laboratory Practice for the Purity of Water, NISTIR 7383, (2019)

GLP 13 Good Laboratory Practice for Drying "To Contain" Volume Standards, NISTIR 7383, (2019)

GMP 3 Good Measurement Practice for Method of Reading a Meniscus Using Water or Other Wetting Liquid, NISTIR 7383, (2019)

GMP 6 Good Measurement Practice for Cleaning Metal Volumetric Measures, NISTIR 7383, (2019)

GMP 7 Good Measurement Practice for Cleaning Precision Glassware, NISTIR 7383, (2019)

GMP 10 Good Measurement Practice for Understanding Factors Affecting Weighing Operations, NISTIR 6969, (2019)

GMP 11 Good Measurement Practice for Assignment and Adjustment of Calibration Intervals for Laboratory Standards, NISTIR 6969, (2019)

NIST SP 811 Guide for the Use of the International System of Unit (SI) 2008 Edition

NIST SP 1038 The International System of Units (SI) — Conversion Factors for General Use (May 2006)

NISTIR 6969 Selected Laboratory and Measurement Practices to Support Basic Mass Calibrations (2019)

NISTIR 7383 Selected Procedures for Volumetric Calibrations, (2019)

SOP 2 Recommended Standard Operating Procedure for Applying Air Buoyancy Corrections, NISTIR 6969, (2019)

SOP 14 Recommended Standard Operating Procedure for Gravimetric Calibration of Volumetric Standards Using an Electronic Balance, NISTIR 7383, (2019)

SOP 20 Standard Operating Procedure for Standard Deviation and Range Charts, NISTIR 7383, (2019)

SOP 29 Standard Operating Procedure for the Assignment of Uncertainty, NISTIR 6969, (2019)

2.4 *OIML Standards:*[5]

OIML D 10 (ILAC G-24) Guidelines for the Determination of Calibration Intervals of Measuring Instruments (2007)[6]

OIML D 28 Conventional Value of the Result of Weighing in Air (2004)

OIML R111 Weights of Classes E1, E2, F1, F2, M1, M1—2, M2, M2—3 and M3 Part 1: Metrological and Technical Requirements (2004)

2.5 *BIPM Standards:*[7]

GUM: JCGM 100:2008 Evaluation of Measurement Data—Guide to the Expression of Uncertainty in Measurement (Also: ISO/IEC Guide 98-3, same title)

2.6 *EURAMET Standards:*[8]

EURAMET/cg-18/V. 4.0 Guidelines on the Calibration of Non-Automatic Weighing Instruments (2015)

EURAMET/cg-19/V. 3.0 Guidelines on the Determination of Uncertainty in Gravimetric Volume Calibration (2018)

EURAMET/cg-21/V. 2.0 Guidelines on the Calibration of Standard Capacity Measures Using the Volumetric Method (2020)

3. Summary of Practice

3.1 This practice is based upon a determination of the volume of water either contained in or delivered by a volumetric instrument. Procedures are given for setting the meniscus, handling the instruments, weighing, and converting the weight to the appropriate standard volume.

4. Volumetric Stability and Calibration Frequency

4.1 The primary purpose of this practice is to provide uniform procedures that may be used to accurately calibrate a wide variety of volumetric instruments and volumetric laboratory standards. The techniques are simple in concept and can provide reliable results, provided the procedures are followed consistently. Accordingly, the practice provides a means for checking the original calibration of volumetric instruments and for periodic recalibrations as needed. All volumetric instruments should regularly be inspected prior to use to ensure no visible damage or contamination. Calibration intervals for all volumetric instruments may be based on legal requirements, manufacturer's recommendations, control charts of similar types of volumetric instruments, analysis of history related to similar models/types of instruments, use and storage frequency as well as the handling conditions and the content of materials being used. References such as the NISTIR 7383, GMP 11, or OIML D 10 (ILAC G-24) may be used to set and adjust calibration intervals.

4.2 The following examples are provided to assist end users:

4.2.1 Under ideal conditions, borosilicate volumetric glassware will hold its calibration indefinitely provided it is used with care and that it is not exposed to hydrofluoric acid, hot phosphoric acid, or strong, hot alkalis, and that it is not heated above 150 °C when dry. A frosting of the glass surface (viewed when dry) indicates that chemical attack has occurred, and recalibration may be in order. As a precaution, it is recommended that glassware always be inspected prior to use to ensure no visible damage or cracks. Significant damage to glassware that impacts the calibration value is likely to be the result of breakage. Volumetric instruments with obvious breaks or cracks should not be used. Glassware should be calibrated at intervals not to exceed five years unless documentation of stability analysis can be provided to support extension of calibration intervals.

4.2.2 Soda-lime volumetric glassware will become frosted with time because of attack from moisture in the atmosphere as well as from the chemicals mentioned above. In addition, it should not be heated above 90 °C when dry. It is

[4] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

[5] Available from Organisation Internationale de Metrologie Legale (OIML), 11 Rue Turgot, 75009 Paris, France, http://www.oiml.org.

[6] Also available from the International Laboratory Accreditation Cooperation, ILAC Secretariat, PO Box 7507, Silverwater NSW 2128, Australia, https://ilac.org.

[7] Available from Bureau International des Poids et Mesures (BIPM), Pavilion de Breteuil, F-92312, Sèvres Cedex, France, http://www.bipm.org.

[8] Available from EURAMET, Bundesallee 100, 38116 Braunschweig, Germany, http://www.euramet.org.