Designation: E898 – 20

Standard Practice for Calibration of Non-Automatic Weighing Instruments[1]

This standard is issued under the fixed designation E898; 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 applies to the calibration of electronic non-automatic weighing instruments. A non-automatic weighing instrument is a measuring instrument that determines the mass of an object by measuring the gravitational force acting on the object. It requires the intervention of an operator during the weighing process to decide whether the weighing result is acceptable.

1.2 Non-automatic weighing instruments have capacities from a few grams up to several thousand kilograms, with a scale interval typically from 0.1 micrograms up to 1 kilogram. Note that non-automatic weighing instruments are usually referred to as either balances or scales. In this practice, for brevity, non-automatic weighing instruments will be referred to as balances; however, the scope of this practice also includes scales.

1.3 This practice only covers electronic non-automatic weighing instruments where the indication is obtained from a digital display. The measuring principle is usually based on the force compensation principle. This principle is realized either by elastic deformation, where the gravitational force of the object being weighed is measured by a strain gauge that converts the deformation into electrical resistance, or by electromagnetic force compensation, where the gravitational force is compensated for by an electromagnetic counterforce that holds the load cell in equilibrium.

1.4 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.5 *This standard does not purport to be suitable as the sole testing process for weighing systems designated for commercial service under weights and measures regulation. The legal requirements for such instruments vary from region to region, and also depend on specific applications. To determine applicable legal requirements, contact the weights and measures authority in the region where the device is located.*

1.6 *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.*

1.7 *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]

E617 Specification for Laboratory Weights and Precision Mass Standards

2.2 *ISO Standards:*[3]

ISO 9001 Quality Management Systems – Requirements

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

2.3 *OIML Documents and Recommendations:*[4]

D28 Conventional Value of the Result of Weighing in Air

R76-1 Non-automatic Weighing Instruments – Part 1: Metrological and Technical Requirements – Tests

R111-1 Weights of classes E_1, E_2, F_1, F_2, M_{1-2}, M_2, M_{2-3} and M_3 – Part 1: Metrological and Technical Requirements

2.4 *EURAMET Guide:*[5]

Calibration Guide No. 18 Guidelines on the Calibration of Non-automatic Weighing Instruments

2.5 *JCGM Guides:*[6]

JCGM 100 Evaluation of Measurement Data – Guide to the Expression of Uncertainty in Measurement (GUM)

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[1] This practice 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] 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, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.

[4] Available from the Organisation Internationale de Métrologie Légale (OIML), 11 Rue Turgot, 75009 Paris, France, https://www.oiml.org/en.

[5] Available from EURAMET e.V., Bundesallee 100, 38116 Braunschweig, Germany, https://www.euramet.org.

[6] Available from the Bureau International des Poids et Mesures, Pavillon de Breteuil, 92312 Sèvres, France, https://www.bipm.org.

JCGM 200 International Vocabulary of Metrology – Basic and General Concepts and Associated Terms (VIM)

2.6 *ILAC Guideline:*[7]

ILAC-G24 Guidelines for the Determination of Calibration Intervals of Measuring Instruments, ILAC-G24

2.7 *USP General Chapters:*[8]

USP General Chapter 41 Balances

USP General Chapter 1251 Weighing on an Analytical Balance

2.8 *UKAS Guide:*[9]

UKAS LAB 14, Edition 5 In-house Calibration and Use of Weighing Machines

2.9 *Code of Federal Regulations:*[10]

CFR Part 58 Good Laboratory Practice for Nonclinical Laboratory Studies

CFR Part 211 Current Good Manufacturing Practice for Finished Pharmaceuticals

2.10 *FDA Guidance:*[11]

FDA Questions and Answers on Current Good Manufacturing Practices, Good Guidance Practices, Level 2 Guidance – Equipment

For dated references, only the dated version applies to this practice. For undated references, the latest edition (including all amendments) applies to this practice.

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 In this section, the official definitions of the terms are provided, as are, where appropriate, simplified definitions that relate the terms to the scope of this practice.

3.1.2 *accuracy class of weights, n*—class designation of a weight or weight set which meets certain metrological requirements intended to maintain the mass values within specified limits.[12]

3.1.3 *calibration, n*—operation that establishes a relation between the indication of the weighing instrument and the reference weights, including the associated measurement uncertainties.

3.1.3.1 *Discussion*—An operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication.[13]

3.1.4 *conventional mass value, n*—mass value indicated in the calibration certificate of the weight.

3.1.4.1 *Discussion*—The conventional mass value of a body is equal to the mass of a standard that balances this body under conventionally chosen conditions, that is, at 20 °C, a density of the standard of 8000 kg/m^3 in air of density 1.2 kg/m^3.[14]

3.1.5 *coverage factor (k), n*—number larger than one by which a combined standard measurement uncertainty is multiplied to obtain an expanded measurement uncertainty.

3.1.5.1 *Discussion*—The coverage factor (k) is typically calculated based on the applicable degrees of freedom (ν).[13]

3.1.6 *eccentric loading error, n*—error when the load is not placed in the center of the weighing platform.

3.1.6.1 *Discussion*—The deviation in the measurement value caused by asymmetrical placement of the center of gravity of the load relative to the load receptor.[15]

3.1.7 *error, n*—difference between the indicated quantity and the applied quantity.

3.1.7.1 *Discussion*—Error is the measured quantity value minus a reference quantity value.[13]

3.1.8 *linearity, n*—ability of a weighing instrument to follow the linear relationship between a load and the indication.[15]

3.1.9 *maximum capacity, n*—maximum weighing capacity, that is, the maximum capacity whose weight can be determined on a balance.[16]

3.1.10 *maximum permissible error (mpe), n*—limit by which the measured quantity indication can deviate from the nominal applied value.

3.1.10.1 *Discussion*—The extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system.[13]

3.1.11 *measurement standard, n*—realization of the definition of a given quantity, with stated quantity value and associated measurement uncertainty, used as a reference.[13]

3.1.12 *measurement uncertainty, n*—parameter that quantifies how far a measurement value might be away from the true (unknown) value.

3.1.12.1 *Discussion*—The non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used.[13]

3.1.13 *minimum weight, n*—smallest sample weight required for a weighment to just achieve a specified relative accuracy of weighing.[15]

3.1.14 *nominal capacity, n*—nominal value of the weighing capacity, derived from the maximum capacity by rounding it down to a number with less significant digits.[15]

3.1.15 *repeatability, n*—ability of a weighing instrument to provide indications that are close together when weighing the same object several times under reasonably constant test conditions.

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

[8] Available from U.S. Pharmacopeial Convention (USP), 12601 Twinbrook Pkwy., Rockville, MD 20852-1790, http://www.usp.org.

[9] Available from the United Kingdom Accreditation Service (UKAS), 2 Pine Trees, Chertsey Lane, Staines-upon-Thames, TW18 3HR, UK, https://www.ukas.com.

[10] Available from the United States Federal Register, https://www.archives.gov/federal-register.

[11] Available from U.S. Food and Drug Administration (FDA), 10903 New Hampshire Ave., Silver Spring, MD 20993, http://www.fda.gov.

[12] Definition from OIML R111-1.

[13] Definition from JCGM 200 (VIM).

[14] Definition from OIML D28.

[15] Nater, R., Reichmuth, A., Schwartz, R., Borys, M., and Panagiotis, Z., *Dictionary of Weighing Terms*, Springer, ISBN 978-3-642-02013-1, 2009.

[16] Definition from OIML R76-1.

3.1.15.1 *Discussion*—The ability of an instrument to provide results that agree one with the other when the same load is deposited several times and in a practically identical way on the load receptor under reasonably constant test conditions.[16]

3.1.16 *scale interval, n*—the difference between two consecutive indicated values.[16]

3.1.17 *sensitivity, n*—change in indication divided by change in the applied quantity.

3.1.17.1 *Discussion*—The quotient of the change in an indication of a measuring system and the corresponding change in a value of a quantity being measured.[13]

3.2 *Symbols:*

d—scale interval
D—drift, value change with time
d_I—smallest scale interval
E—error of indication
I —indication
k—coverage factor
L—load
m —object mass
Max—maximum capacity
Max_I—upper limit of partial weighing range with smallest scale interval
m_c—conventional value of mass
m_{min}—minimum weight
m_N—nominal mass
mpe—maximum permissible error of a measured quantity
m_{ref}—reference mass
n—number of repeated weighings
R—reading
s—standard deviation
SF—safety factor
T—temperature (unit K)
u—standard uncertainty
U—expanded uncertainty
u_c—combined standard uncertainty
α—intercept (for uncertainty in use)
β—slope (for uncertainty in use)
v—degrees of freedom
v_{eff}—effective degrees of freedom for combined standard uncertainty
ρ—density
ρ_0—reference density of air, ρ_0 = 1.2 kg/m^3
ρ_c—reference density of mass, ρ_c = 8000 kg/m^3
ρ_S—density of standard weights

3.3 *Symbol Subscripts and Definitions*

Subscript	Related
B	air buoyancy
conv	convection
D	drift
L	load
N	nominal value
dig	digitization
ecc	load in different locations on the weighing pan
i, j	number
max	maximum
min	minimum
ref	reference
rep	repeatability
0	no load

4. Significance and Use

4.1 This practice will enable calibration laboratories and the user to calibrate electronic non-automatic weighing instruments and quantify the error of the balance throughout the measurement range, usually from zero to maximum capacity. The error of indication is accompanied by a statement on measurement uncertainty, which is individually estimated for every measurement point. This practice is based on the test procedures and uncertainty estimation described in the EURAMET calibration guide cg-18. However, while EURAMET cg-18 allows for a very flexible execution of the measurements, the test procedures described in this practice are more fixed to enable a better comparability between calibrations executed by different calibration laboratories or users. This practice may also serve as basis for accreditation of calibration laboratories for calibration of electronic non-automatic weighing instruments.

4.2 This practice allows the user to decide whether the calibrated balance is fit for its intended purpose, based on the assessment of the calibration results. Usually, this assessment is done by ensuring that the measurement uncertainty of all weighings the user performs on the instrument is smaller than a specified relative tolerance established by the user. This approach is commensurate to assuring that the smallest net amount of substance that the user weighs on the instrument (so-called smallest net weight) is larger than the minimum weight, which is derived from the calibration results.

4.3 This practice, in Appendix X2, provides information on the periodic performance verification on the balance that should be carried out by the user between the calibrations. Calibration together with periodic performance verification allows the user to ensure with a very high degree of probability that the balance meets the user requirements during its day-to-day usage. It helps users comply with requirements from other standards or regulations that stipulate periodic tests and calibrations of quality-relevant instruments.

5. Calibration Conditions

5.1 *Standard Weights*

5.1.1 *General Requirements*—Test loads shall consist of standard weights that are traceable to the SI unit of mass, with the possible exception of test loads used for measurements of a comparative nature—for example, measurement of eccentric loading or repeatability.

5.1.2 *Standard Weight Traceability*—The traceability of weights to be used as standards shall be demonstrated by calibration consisting of:

5.1.2.1 Determination of the conventional value of mass m_c or the correction δm_c to its nominal value m_N:$\delta m_c = m_c - m_N$, or both, together with the expanded uncertainty of the calibration U, or

5.1.2.2 Confirmation that m_c is within specified maximum permissible errors mpe: $m_N - (mpe - U) \leq m_c \leq m_N + (mpe - U)$.

5.1.2.3 The standards should further satisfy the following requirements to an extent appropriate to their accuracy: