Designation: E4 – 21

American Association State
Highway and Transportation Officials Standards
AASHTO No: T67

Standard Practices for Force Calibration and Verification of Testing Machines[1]

This standard is issued under the fixed designation E4; 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 These practices cover procedures for the force calibration and verification, by means of force measurement standards, of tension or compression, or both, static or quasi-static testing machines (which may, or may not, have force-indicators). These practices are not intended to be complete purchase specifications for testing machines.

1.2 Testing machines may be verified by one of the three following methods or combination thereof. Each of the methods require a specific measurement uncertainty, displaying metrological traceability to The International System of Units (SI).

1.2.1 Use of standard weights,

1.2.2 Use of equal-arm balances and standard weights, or

1.2.3 Use of elastic force measurement standards.

1.3 The procedures of 1.2.1–1.2.3 apply to the calibration and verification of the force-measuring systems associated with the testing machine, including the force indicators such as a scale, dial, marked or unmarked recorder chart, digital display, etc. *In all cases the buyer/owner/user must designate the force-measuring system(s) to be verified and included in the certificate and report of calibration and verification.*

1.4 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system are not necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the other, and values from the two systems shall not be combined.

1.4.1 Other non-SI force units may be used with this standard such as the kilogram-force (kgf) which is often used with hardness testing machines

1.5 Forces indicated on displays/printouts of testing machine data systems—be they instantaneous, delayed, stored, or retransmitted—which are verified with provisions of 1.2.1, 1.2.2, or 1.2.3, and are within the specifications stated in Section 15, comply with Practices E4.

1.6 The requirements of these practices limit the major components of measurement uncertainty when calibrating testing machines. These Standard Practices do not require the allowable force measurement error to be reduced by the amount of the measurement uncertainty encountered during a calibration. As a result, a testing machine verified using these practices may produce a deviation from the true force greater than ±1.0 % when the force measurement error is combined with the measurement uncertainty.

1.7 *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.*

1.8 *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]

E6 Terminology Relating to Methods of Mechanical Testing

E74 Practices for Calibration and Verification for Force-Measuring Instruments

E467 Practice for Verification of Constant Amplitude Dynamic Forces in an Axial Fatigue Testing System

2.2 *BIPM Standard:*[3]

JCGM 100 : Evaluation of measurement data - Guide to the Expression of Uncertainty in Measurement.

[1] These practices are under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.01 on Calibration of Mechanical Testing Machines and Apparatus.

Current edition approved June 1, 2021. Published August 2021. Originally approved in 1923. Last previous edition approved in 2020 as E4 – 20. DOI: 10.1520/E0004-21.

[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 BIPM - Pavillon de Breteuil F-92312 Sèvres Cedex FRANCE. this document is available free-of-charge at https://www.bipm.org/en/publications/guides/vim.html

***A Summary of Changes section appears at the end of this standard**

JCGM 200 : International vocabulary of metrology — Basic and general concepts and associated terms (VIM).

3. Terminology

3.1 For definitions of terms used in this practice, refer to Terminology E6.

3.2 *Definitions:*

3.2.1 *calibration, n*—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.

3.2.1.1 *Discussion*—A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

3.2.1.2 *Discussion*—Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", nor with verification of calibration.

3.2.1.3 *Discussion*—Often, the first step alone in the above definition is perceived as being calibration. **JCGM 200:2012** [4]

3.2.2 *elastic force measurement standard, n*—system consisting of an elastic member combined with an appropriate device for indicating the magnitude (or a quantity proportional to the magnitude) of deformation of the member under an applied force.

3.2.3 *exercise, v*—apply the maximum force to be used in the calibration to either an elastic force measurement standard or the force-sensing device of a testing machine, or to both, to reestablish the hysteresis pattern that tends to disappear during periods of disuse, or with the change of mode of force application, as from compression to tension.

3.2.4 *force indicator, n—of a testing machine*, a component of a force-measuring system that presents, in force units, the force measured by the force-measuring system.

3.2.5 *force measurement error, E, n*—in the case of a testing machine, the difference obtained by subtracting the force indicated by the force measurement standard from the indicated force of the testing machine.

3.2.5.1 *Discussion*—In a certificate and report of calibration and verification, "force measurement error" shall be used with numerical values, for example, "At a force of 300 kN [60 000 lbf], the force measurement error of the testing machine was + 67 N [+ 15 lbf]."

3.2.6 *force measurement standard, n*—a standard weight, an equal-arm balance and a standard weight, or an elastic force measurement standard used as a reference, with associated measurement uncertainty, in compliance with these practices and Practices E74.

3.2.6.1 *Discussion*—A force measurement standard is a specific type of "measurement standard" as defined in JCGM 200: International vocabulary of metrology — Basic and general concepts and associated terms (VIM).

3.2.7 *force-measuring system, n—of a testing machine*, a component of a testing machine that measures and indicates the force applied by the testing machine.

3.2.8 *force-sensing device, n—of a testing machine*, a component of the force-measuring system, that measures through deformation or other means the force applied by the testing machine.

3.2.8.1 *Discussion*— Examples of a force-sensing device include a strain-gage force transducer (commonly called a load cell) and a pressure transducer.

3.2.9 *measurement accuracy, n*—closeness of agreement between a measured quantity value and a true quantity value of a measurand.

3.2.9.1 *Discussion*—The concept "measurement accuracy" is not a quantity and is not given a numerical quantity value. A measurement is said to be more accurate when it offers a smaller measurement error.

3.2.9.2 *Discussion*—The term "measurement accuracy" should not be used for measurement trueness and the term "measurement precision" should not be used for 'measurement accuracy', which, however, is related to both these concepts.

3.2.9.3 *Discussion*—"Measurement accuracy" is sometimes understood as closeness of agreement between measured quantity values that are being attributed to the measurand. **JCGM 200:2012** [4]

3.2.10 *metrological traceability, n*—property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty.

3.2.10.1 *Discussion*—For this definition, a "reference" can be a definition of a measurement unit through its practical realization, or a measurement procedure including the measurement unit for a non-ordinal quantity, or a measurement standard.

3.2.10.2 *Discussion*—Metrological traceability requires an established calibration hierarchy.

3.2.10.3 *Discussion*—Specification of the reference must include the time at which this reference was used in establishing the calibration hierarchy, along with any other relevant metrological information about the reference, such as when the first calibration in the calibration hierarchy was performed.

3.2.10.4 *Discussion*—For measurements with more than one input quantity in the measurement model, each of the input quantity values should itself be metrologically traceable and the calibration hierarchy involved may form a branched structure or a network. The effort involved in establishing metrological traceability for each input quantity value should be commensurate with its relative contribution to the measurement result.

3.2.10.5 *Discussion*—Metrological traceability of a measurement result does not ensure that the measurement uncertainty is adequate for a given purpose or that there is an absence of mistakes.

[4] This definition is reproduced here from JCGM 200:2012 International vocabulary of metrology – Basic and general concepts and associated terms (VIM) with permission from the Director of BIPM. The text has been put in ASTM International's form and style.