
Standard Practice for

**Establishing Requirements for and
Performing Equipment Calibrations,
Standardizations, and Checks**

AASHTO Designation: PP 57-06 (2009)¹



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1. SCOPE

- 1.1. This document contains general criteria and guidelines for establishing requirements for and performing equipment calibrations, verification of calibrations, standardizations, and checks.

2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
 - T 201, Kinematic Viscosity of Asphalts (Bitumens)
 - T 245, Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
- 2.2. *International Standards:*
- *International Vocabulary of Basic and General Terms in Metrology* (VIM), second edition. International Organization for Standardization, Geneva, Switzerland, 1993.
 - ISO/IEC 17025, General Requirements for the Competence of Testing and Calibration Laboratories.
 - *ISO Guide to the Expression of Uncertainty in Measurement* (GUM). International Organization for Standardization, Geneva, Switzerland, 1995. The U.S. edition of the GUM is entitled *American National Standard for Expressing Uncertainty—U.S. Guide to the Expression of Uncertainty in Measurement*, ANSI/NCSL Z540-2-1997.

3. TERMINOLOGY

- 3.1. *accuracy of measurement*—closeness of the agreement between the result of a measurement and a true value of the measurand (VIM, Section 3.5).
- 3.1.1. *Discussion*—Part 1 of the international standard ISO 5725-1 on the accuracy of measurement methods and results defines accuracy as the closeness of agreement between a test result and the accepted reference value. This definition is supplemented by a note that states that the term accuracy, when applied to a set of test results, involves a combination of random components and a common systematic error or bias component. Accuracy is thus viewed as a characteristic of a measurement process consisting of precision as well as bias components. A process is considered to be accurate only if it is precise as well as unbiased.

The expanded uncertainty of a measurement, discounting the bias, is equivalent to the accuracy of the measurement after a correction or correction factor is applied.

- 3.2. *calibration, n*—a set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or between values represented by a material measure or a reference material, and the corresponding values realized by standards (VIM, Section 6.11).
- 3.2.1. *Example*—Balances (measurement instrument), Dynamic Shear Rheometer (measuring system), Pycnometer (material measure).
- 3.2.2. *Discussion*—The purpose of calibration is to ensure that measurements made by the laboratory are traceable to the International System of Units (SI). Where traceability of measurements to SI units is not possible or relevant, measurements must be traceable to certified reference materials, agreed methods, or consensus standards. Uncertainty estimates obtained during calibration are used to judge if an instrument is suitable for its intended purpose. There is a need to re-establish traceability or recalibrate only when instrument measurements drift out of control [as determined through verification of calibration (Section 3.10)].
- 3.3. *check, n*—a specific type of inspection and/or measurement performed on the physical properties of equipment and materials to determine compliance or otherwise with stated criteria.
- 3.4. *correction, n*—value added algebraically to the uncorrected result of a measurement to compensate for systematic error (VIM, Section 3.15).
- 3.4.1. *Discussion*—Because the systematic error cannot be known perfectly, the correction can only be an estimate.
- 3.5. *correction factor, n*—numerical factor by which the uncorrected result of a measurement is multiplied to compensate for systematic error (VIM, Section 3.16).
- 3.5.1. *Discussion*—Because the systematic error cannot be known perfectly, the correction factor can only be an estimate.
- 3.6. *standard, n*—material measure, measuring instrument, reference material, or measuring system intended to define, realize, conserve, or reproduce a unit of one or more values of a quantity to serve as a reference (VIM, Section 6.1).
- 3.7. *standardization, n*—a process that determines (1) the correction or correction factor to be applied to the result of a measuring instrument, measuring system, material measure, or reference material when its values are compared to the values realized by standards, (2) the adjustment to be applied to a piece of equipment when its performance is compared with that of an accepted standard or process.
- 3.7.1. *Discussion*—Standardization in case (1) is a simplified form of calibration that estimates systematic error but does not identify random error. Standardization, therefore, does not address all of the elements of uncertainty of measurement and does not lead to traceable measurements. An example of case (2) standardization is adjusting the number of blows of a mechanically operated hammer so it applies the energy equivalent to that of a manually operated hammer.
- 3.8. *traceability, n*—the property of the result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties (VIM, Section 6.10).

- 3.8.1. *Discussion*—There is a need for traceable measurements. Measurements, not the instrument, can be traceable. Measurement traceability is established through calibration. Measurement traceability is maintained through verification of calibration (a regular check of instrument output using a control standard).
- 3.9. *uncertainty of measurement, n* —parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand (VIM, Section 3.10).
- 3.9.1. *Discussion*—The uncertainty of a measurement is required in order to establish its traceability. An evaluation of the uncertainty of measurement is conducted to determine if measurement equipment is fit for purpose.
- The expanded uncertainty of a measurement, discounting the bias, is equivalent to the accuracy of the measurement after a correction or correction factor is applied.
- 3.9.2. The definitions of various uncertainty terms used in the GUM are:
- *Standard uncertainty*—uncertainty of the result of a measurement expressed as a standard deviation.
 - *Combined standard uncertainty*—standard uncertainty of the result of a measurement when that result is obtained from the values of a number of other quantities, equal to the positive square root of the sum of the terms, the terms being the variances or covariance of these other quantities weighed according to how the measurement result varies with change in these quantities.
 - *Expanded uncertainty*—quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurement.
 - *Coverage factor*—numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty. The coverage factor k is typically in the range of 2 to 3.
- 3.10. *verification of calibration, n* —a process that establishes whether the results of a previously calibrated measurement instrument, measurement system, material measure, or reference material are in control.
- 3.10.1. *Discussion*—Verification of calibration is used to maintain the traceability of a measurement and to determine when to recalibrate. Control charts should be used to plot verification results and determine if instrument measurements have drifted out of control.
- 3.11. *verification of standardization, n* —a process that establishes whether the results of a previously standardized measurement instrument, measurement system, material measure, or reference material are in control.
- 3.11.1. *Discussion*—Verification of standardization is used to indicate when a shift in the population average occurs and when it is time to re-standardize. Control charts should be used to plot verification results and determine if instrument measurements have drifted out of control.

4. SIGNIFICANCE AND USE

- 4.1. Construction material test standards can be improved if equipment calibrations, standardizations, and checks are properly specified and if each activity and its requirements are understood.

- 4.2. The guidance in this document is intended to be used by standards developers in the selection of terms used in methods and in the establishment of appropriate requirements for equipment calibrations, standardizations, and checks.
- 4.3. The guidance in this document can also be used by laboratories for performing equipment calibrations, standardizations, and checks.

5. GUIDANCE FOR STANDARDS DEVELOPERS

- 5.1. *Calibration or Standardization versus Checking*—Most measuring instruments, measuring systems, and material measures should be either calibrated or standardized. Checking applies to test equipment that is not a measuring instrument, measuring system, or material measure such as an oven, straightedge, or specimen mold.
- 5.2. *Determining if Equipment Checks Are Necessary*—The primary consideration in deciding whether a piece of test equipment should be checked is the equipment's influence on the test result. If the physical properties of a piece of equipment could significantly influence the test result, then routine checks to determine compliance or otherwise with stated criteria are essential. However, if the physical properties of a piece of test equipment are not likely to affect the test result, routine equipment checks are not necessary.
- 5.3. *Calibration versus Standardization*—The two primary considerations for making the decision to calibrate or standardize a measuring instrument, measuring system, or material measure are (1) the measurement's influence on the test result and (2) the probability that the uncertainty of measurement could exceed the accuracy requirement of the measurement. Refer to Table 1 for guidance for determining whether to specify equipment calibration, standardization, or nothing.

Table 1—Guidance for Determining Whether Equipment Shall Be Calibrated, Standardized, or Neither

		Probability That the Uncertainty of Measurement Could Exceed the Accuracy Requirement of the Measurement		
		Low	Moderate	High
Measurement's Influence on the Test Result	High	Standardize	Calibrate	Calibrate
	Moderate	Standardize	Standardize	Calibrate
	Low	Nothing	Standardize	Standardize

- 5.4. *Selecting and Specifying Intervals for Equipment Calibrations, Standardizations, and Checks*—Equipment calibration, standardization, and check intervals shall be specified in the test methods (Notes 1 and 2). The two primary considerations for determining an acceptable interval are (1) the probability that time and/or usage will affect the instrument or device and (2) the measurement's or device's influence on the test result. Refer to Table 2 for guidance for determining intervals between calibrations, standardizations, and checks.