Designation: C670 – 24a

Standard Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials[1]

This standard is issued under the fixed designation C670; 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 The *Form and Style for ASTM Standards* requires that all test methods contain statements on precision and bias. Further, the precision statement is required to contain a statement on single-operator precision (repeatability) and a statement on multilaboratory precision (reproducibility). This practice provides guidance for preparing precision and bias statements that comply with these requirements. Discussion of the purpose and significance of precision and bias statements for users of test methods is also provided. Examples of precision statements that conform to this practice are included in Appendix X1. This practice supplements Practice E177 and has been developed to meet the needs of ASTM Committees dealing with construction materials.

NOTE 1—Although this practice is under the jurisdiction of Committee C09, the current version was developed jointly by Committees C01 and C09 and has subsequently been adopted for use by other committees dealing with construction materials.

1.2 This practice assumes that an interlaboratory study (ILS) has been completed in accordance with Practice C802 or Practice E691. The interlaboratory study provides the necessary statistical values to write the precision and bias statements.

1.3 The system of units for this practice is not specified. Dimensional quantities in the practice are presented only in examples of precision and bias statements.

1.4 *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.*

1.5 *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]

C802 Practice for Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods for Construction Materials

C1067 Practice for Conducting a Ruggedness Evaluation or Screening Program for Test Methods for Construction Materials

D6607 Practice for Inclusion of Precision Statement Variation in Specification Limits

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E456 Terminology Relating to Quality and Statistics

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general statistical terms, refer to Terminology E456.

3.2 *Definitions of Terms Specific to This Standard:*[3]

3.2.1 *test determination, n*—the value of a characteristic of a single test specimen obtained by a specified test method.

3.2.1.1 *Discussion*—The term "replicate" is often used for each test determination if multiple determinations are required to obtain a test result (see 4.1).

3.2.2 *test result, n*—the value of a characteristic of a material obtained by carrying out a specified test method.

3.2.2.1 *Discussion*—A test result may be a single test

[1] This practice is under the jurisdiction of ASTM Committee C09 on Concrete and Concrete Aggregates and is the direct responsibility of Subcommittee C09.94 on Evaluation of Data (Joint C09 and C01).

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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] Terms are listed in order of hierarchy beginning with the basic concept.

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

determination or the average of a specified number of test determinations, or replicates (see 4.1).

3.2.3 *identical test specimens, n*—test specimens selected at random and made from a single quantity or batch of material that is as homogeneous as possible.

3.2.3.1 *Discussion*—In interlaboratory studies of test methods for fresh cementitious mixtures, a practicable approach for obtaining identical tests specimens is to assemble technicians from different laboratories at one location and test specimens are made from the same batch of the fresh mixture. For interlaboratory studies of nondestructive test methods, the same test specimens can be circulated among participating laboratories, provided the characteristic of interest does not change during the time to complete the study.

3.2.4 *single-operator standard deviation, s_r, (or coefficient of variation, CV_r), n*—the standard deviation (or coefficient of variation) of test determinations obtained on identical test specimens by a single operator using the same apparatus in the same laboratory over a relatively short period of time.

3.2.4.1 *Discussion*—The single-operator standard deviation, or coefficient of variation, is the fundamental statistic underlying the single-operator indexes of precision. The single-operator standard deviation, or coefficient of variation, is an indication of the variability of a large number of test determinations by the same operator on the same material. This value is obtained from an interlaboratory study and is equal to the pooled standard deviation of test determinations obtained by the operators. The coefficient of variation (ratio of standard deviation to the average expressed as a percentage) is used if the standard deviation is proportional to the level of the characteristic being measured. The single-operator standard deviation, usually considered a property of the test method, will generally be lower than the multilaboratory standard deviation. In Practice E177, the single-operator standard deviation is referred to as the *repeatability standard deviation*, and the subscript *r* is used. In previous versions of Practice C670, the terms *one-sigma limit (1s)* or *one sigma limit in percent (1s%)* were used for the single-operator standard deviation or single-operator coefficient of variation, respectively. In some publications, the term *within-test standard deviation* (or *coefficient of variation*) has been used. The term *within-laboratory standard deviation* (or coefficient of variation) should not be used for this statistic (see 4.2.3).

3.2.5 *multilaboratory standard deviation, s_R (or coefficient of variation, CV_R), n*—the standard deviation or coefficient of variation of test results obtained with the same test method on identical test specimens in different laboratories with different operators using different equipment.

3.2.5.1 *Discussion*—The multilaboratory standard deviation, or coefficient of variation, is the fundamental statistic underlying the indexes of precision under multilaboratory conditions. The multilaboratory standard deviation is an indication of the variability of test results obtained by different laboratories for identical test specimens. The multilaboratory standard deviation (or coefficient of variation) is usually greater than the single-operator standard deviation (or coefficient of variation), because different operators and different apparatus have been used in different laboratories for which the environments may have differed. These factors may lead to a between-laboratory component of variance that is determined from the interlaboratory study and contributes to the multilaboratory variance. In Practice E177, the multilaboratory standard deviation is referred to as the *reproducibility standard deviation* and the subscript *R* is used.

3.2.6 *difference limit (d2s or d2s%), n*—the difference between two test results that is expected to be exceeded with a probability of about 5 % in the normal and correct operation of the test method; used as an index of precision of the test method.

3.2.6.1 *Discussion*—The difference limit has been selected as the appropriate index of precision in most precision statements. A difference limit (d2s) indicates the maximum acceptable difference between two test results obtained on identical test specimens (see 3.2.3.1) under the applicable system of causes (single-operator or multilaboratory conditions). The (d2s%) limit is the maximum acceptable difference between two test results expressed as a percentage of their average. These difference limits are calculated by multiplying the appropriate standard deviation (s_r or s_R) or coefficient of variation (CV_r or CV_R) by the factor $1.96\sqrt{2}$, which for the purpose of this Practice is taken to be equal to 2.8. In Practice E177, the terms *repeatability limit* and *reproducibility limit* are used for these difference limits under single-operator and multilaboratory conditions, respectively.

3.2.7 *acceptable range, n*—the difference between the largest and smallest of three or more test determinations or test results that is expected to be exceeded with a probability of about 5 % in the normal and correct operation of the test method; used as an index of precision of the test method, if applicable.

3.2.7.1 *Discussion*—This index is usually reported in precision statements of test methods that define a test result as the average of three or more determinations. Otherwise, the difference limit (d2s or d2s%) is used. See 4.3 for additional discussion on how to determine this index.

4. General Concepts

4.1 *Test Result*—The result of a test method may be a single test determination or the average of two or more test determinations (or replicates). The precision statement of a test method applies to a test result as defined in the test method and the statement should indicate what constitutes a test result.

4.1.1 *Number of Test Determinations*—The number of test determinations required to obtain a test result by a test method must be taken into account when evaluating testing variations. The statistic used in evaluating single-operator precision is based on the standard deviation (or coefficient of variation) of single test determinations.

4.1.2 *Test Result Based on Averages of Determinations*—For test methods that define a test result as the average of two or more test determinations (or replicates), the fundamental statistic is still the standard deviation (or coefficient of variation) of single test determinations. The report of the analysis of the interlaboratory study (see 5.2) must include this statistic.