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Standard Practice for Statements on Number of Specimens for Textiles[1]

This standard is issued under the fixed designation D 2905; 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 Department of Defense.

1. Scope

1.1 This practice provides a mechanism for calculating the number of specimens per laboratory sampling unit. It also provides recommended texts to be used in exceptional cases. Ordinarily, it is preferable to specify in the section on sampling a small fixed number of specimens for each laboratory sampling unit. Occasionally, however, the task group writing a test method may think that the variability among the observations on specimens within a laboratory sampling unit will probably differ significantly from laboratory to laboratory. It is in unusual cases of this sort that the recommended texts in this practice should be used.

1.1.1 Paragraph A14.8 of the *Recommendations on Form and Style* specifies that statements on the number of specimens be included in all test methods.

1.2 This practice covers six optional recommended texts which serve as guides for the preparation of statements on the number of specimens required to determine the average quality of each unit of the laboratory sample under various conditions. The choice of the text to be used in a specific method will depend on the purpose of the test and the available information. This practice covers the following six different conditions.

Recommended Text	Conditions	Sections
1	Standard Deviation with Two-sided Limits	10, 11
2	Standard Deviation with One-sided Limits	13, 14
3	Coefficient of Variation with Two-sided Limits	16, 17
4	Coefficient of Variation with One-sided Limits	19, 20
5	Variability Known, Fixed Number of Specimens	22
6	Variability Not Known, Fixed Number of Specimens	24

1.3 Recommended Texts 1 through 4 are preceded by examples. Each example states part of the data from an interlaboratory test and illustrates the decisions needed in the course of calculating the numerical values required for inclusion in a specific text. Each of these texts describes two conditions: (*1*) the procedure to be followed when the user has a reliable estimate of the variability of the method in his own laboratory, and (*2*) the fixed number of specimens required when the user does not have a reliable estimate of the variability of the method in his own laboratory.

1.4 The instructions in this practice are specifically applicable to methods based on the measurement of variates. The instructions are not generally applicable to data based on attributes, and as a result, are not usually used for methods based on "go, no-go" tests.

1.5 This practice does not specify or discuss sampling plans but assumes that sampling has been adequately covered in other sections of the test method under preparation. However, to obtain the total number of specimens on which to base a decision to accept or reject a lot when acceptance testing a commercial shipment, multiply the number of specimens for each unit or the laboratory sample by the total number of such units in the entire lot sample. Instructions on the number of units in the laboratory sample to be taken from each of the primary sampling units in the lot sample should be in the applicable material specification or other agreement between the purchaser and the supplier.

2. Referenced Documents

2.1 *ASTM Standards:*

D 123 Terminology Relating to Textiles[2]

D 2904 Practice for Interlaboratory Testing of a Textile Test Method that Produces Normally Distributed Data[2]

D 2906 Practice for Statements on Precision and Bias for Textiles[2]

D 4271 Practice for Writing Statements on Sampling in Test Methods for Textiles[3]

E 122 Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process[4]

E 456 Terminology Relating to Quality and Statistics[4]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[4]

2.2 *ASTM Adjuncts:*

[1] This practice is under the jurisdiction of ASTM Committee D13 on Textiles and is the direct responsibility of Subcommittee D13.93 on Statistics.

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[2] *Annual Book of ASTM Standards,* Vol 07.01.

[3] *Annual Book of ASTM Standards*, Vol 07.02.

[4] *Annual Book of ASTM Standards,* Vol 14.02.

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TEX-PAC[5]

NOTE 1—Tex-Pac is a group of PC programs on floppy disks, available through ASTM Headquarters, 100 Barr Harbor Drive, West Conshohocken, PA 19428, USA. The calculations for the numbers of specimens described in the various sections of this practice can be performed using one of the programs in this adjunct.

3. Terminology

3.1 *Definitions:*

3.1.1 *accuracy*, *n—of a test method*, the degree of agreement between the true value of the property being tested (or accepted standard value) and the average of many observations made according to the test method, preferably by many observers. See also *bias* and *precision*.

3.1.1.1 *Discussion*—Increased accuracy is associated with decreased bias relative to the true value; two methods with equal bias relative to the true value have equal accuracy even if one method is more precise than the other. The true value is the exact value of the property being tested for the statistical universe being sampled. When the true value is not known or cannot be determined, and an acceptable standard value is not available, accuracy cannot be established. No valid inferences on the accuracy of a method can be drawn from an individual observation.

3.1.2 *bias*, *n—in statistics*, a constant or systematic error in test results.

3.1.2.1 *Discussion*—Bias can exist between the true value and a test result obtained from one method; between test results obtained from two methods; or between two test results obtained from a single method, for example, between operators or between laboratories.

3.1.3 *coefficient of variation, CV*, *n*—a measure of the dispersion of observed values equal to the standard deviation for the values divided by the average of the values; may be expressed as a percentage of the average (CV %).

3.1.4 *determination value*, *n*—the numerical quantity calculated by means of the test method equation from the measurement values obtained as directed in a test method. (Syn. *determination*.)

3.1.5 *laboratory sample*, *n*—a portion of material taken to represent the lot sample, or the original material, and used in the laboratory as a source of test specimens.

3.1.6 *percentage point*, *n*—a difference of 1 % of a base quantity.

3.1.6.1 *Discussion*—A phrase such as "difference of *X* %" is ambiguous when referring to a difference in percentages. For example, a change in the moisture regain of a material from 5 % to 7 % could be reported as an increase of 40 % of the initial moisture regain or as an increase of two percentage points. The latter wording is recommended.

3.1.7 *precision*, *n*—the degree of agreement within a set of observations or test results obtained as directed in a method.

3.1.7.1 *Discussion*—The term "precision," delimited in various ways, is used to describe different aspects of precision. This usage was chosen in preference to the use of "repeatability" and "reproducibility" which have been assigned conflicting meanings by various authors and standardizing bodies.

3.1.8 *precision*, *n—under conditions of single-operator precision*, the single-operator-laboratory-sample-apparatus-day precision of a method; the precision of a set of statistically independent observations all obtained as directed in the method and obtained over the shortest practical time interval in one laboratory by a single operator using one apparatus and randomly drawn specimens from one sample of the material being tested.

3.1.8.1 *Discussion*—Results obtained under conditions of single-operator precision represent the optimum precision that can be expected when using a method. Results obtained under conditions of within-laboratory and between-laboratory precision represent the expected precision for successive test results when a method is used respectively in one laboratory and in more than one laboratory.

3.1.9 *precision*, *n—under conditions of within-laboratory precision with multiple operators*, the multi-operator, single-laboratory-sample, single-apparatus-day (within operator) precision of a method; the precision of a set of statistically independent test results all obtained in one laboratory using a single sample of material and with each test result obtained by a different operator, with each operator using one apparatus to obtain the same number of observations by testing randomly drawn specimens over the shortest practical time interval.

3.1.10 *precision*, *n—under conditions of between-laboratory precision*, the multi-laboratory, single-sample, single-operator-apparatus-day (within-laboratory) precision of a method; the precision of a set of statistically independent test results all of which are obtained by testing the same sample of material and each of which is obtained in a different laboratory by one operator using one apparatus to obtain the same number of observations by testing randomly drawn specimens over the shortest practical time interval.

3.1.11 *specimen*, *n*—a specific portion of a material or a laboratory sample upon which a test is performed or which is selected for that purpose. (Syn. *test specimen*.)

3.1.12 *standard deviation, s*, *n— of a sample*, a measure of the dispersion of variates observed in a sample expressed as the positive square root of the sample variance.

3.1.13 *test result*, *n*—a value obtained by applying a given test method, expressed as a single determination or a specified combination of a number of determinations.

3.1.14 *variance* s^2, *n— of a sample*, a measure of the dispersion of variates observed in a sample expressed as a function of the sum of the squared deviations from the sample average.

3.1.15 For definitions of other terms used in this practice, refer to Terminology D 123. For definitions of statistical terms refer to Terminology D 123 and Terminology E 456.

4. Significance and Use

4.1 *Standard Deviations versus Coefficients of Variation*—The term "standard deviation" is used throughout this section. Where it is applicable, the term "coefficient of variation" may be substituted. It should be realized, however, that the coefficient of variation should be used in a test method to describe variability only when the standard deviation has been found to

[5] PC programs on floppy disks are available through ASTM. Request ADJD2904.

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increase in direct proportion to the average for determinations at different levels of the property of interest.

4.2 *Fixed Number of Determinations*— For most test methods, the variability for individual determinations will be relatively constant from laboratory to laboratory. For this reason, it is usually advisable to specify some small fixed number of determinations to be made on each laboratory sampling unit rather than to use the procedures given in this practice. The task group can determine the value of the fixed number of specimens per laboratory sampling unit using Eq 2 or Eq 3.

4.2.1 A small fixed number of determinations on each laboratory sampling unit is practical because the estimated variance for averages of all determinations on the entire lot sample is based on Eq 1:

$$V(A) = V(L)/n + V(T)/mn + V(E)/kmn \quad (1)$$

where:

$V(A)$ = estimated variance for the average of all determinations on the entire lot sample,
$V(L)$ = component of variance due to lot sampling units,
$V(T)$ = component of variance due to laboratory sampling units within lot sampling units,
$V(E)$ = component of variance due to specimens within laboratory sampling units,
n = number of lot sampling units in the lot sample,
m = number of laboratory sampling units per lot sampling unit, and
k = number of specimens (determinations) per laboratory sampling unit.

4.2.2 Eq 1 shows that only $V(E)$, the component of variance due to specimens, is affected by the number of specimens per laboratory sampling unit. Instead of testing a relatively large number of specimens per laboratory sampling unit, it is usually more cost effective to increase the divisor for $V(E)$ by increasing m, the number of laboratory sampling units per lot sampling unit, or n, the number of lot sampling units in the lot sample, or both. Increasing m or n or both not only decreases the contribution of $V(E)$, but also decreases the contribution of $V(T)$ or of both $V(L)$ and $V(T)$.

4.3 *Calculated Number of Determinations*—In those cases where the authors of a test method think that the variability for individual determinations is likely to vary significantly from laboratory to laboratory, they may wish to specify a number of specimens per laboratory sampling unit, k, that is a function of the observed variability. This practice provides a procedure for determining the value of k under such conditions.

4.3.1 In cases where k is to be calculated, the task group needs also to specify a fixed value of k to be used when an estimate of the variability for determinations within a laboratory sampling unit is not available. In the absence of the necessary information, it is advisable for such a fixed value of k to be somewhat larger than would ordinarily be obtained from an estimate of the variability of determinations in a user's laboratory. Such a fixed value of k is normally obtained by using a value of the variability, that is 1.414 times the best estimate for a typical value of the variability. This procedure will result in a calculated value of k that is twice what would be obtained from the typical value of the variability. See 12.1.2, 15.1.2, 18.1.2, and 21.1.2 for examples of calculations of a fixed number of specimens per laboratory sampling unit when there is not a good estimate of variability which was obtained in the user's laboratory.

5. Basis for Calculations

5.1 In order to determine the number of specimens required, information is needed on the variability of individual observations made as directed in the method to be used. The variability of individual observations depends upon the test method itself, upon the experience and training of the operator, upon the calibration and maintenance of the apparatus used, and especially upon the variability of the property in the material being tested. For this reason, it is preferable for the user of the test to determine the variability of individual observations experimentally under the actual test conditions of interest and upon specimens from the types of material to be tested by use of the method. Less satisfactorily, the user may act on information obtained by using the proposed method on typical materials before the method was published. Such general information is usually obtained as directed in Practice D 2904 or Practice E 691 and is reported in the section of the method on Precision and Bias as directed in Practice D 2906.

5.2 In addition to the variability of individual observations, the required number of specimens depends upon the values *chosen* for the allowable variation and probability level. Both of these factors are based on engineering judgment, but the original recommendations of the task group preparing the method must be approved by the members of the subcommittee.

5.3 The recommendations in this standard consider only the variability of individual observations made under conditions of single-operator precision. Other sources of variation, such as differences between instruments, operators, laboratories, or differences with time may also have to be taken into account when certain test methods are being written or revised. For a general discussion of the precision that can be expected with different numbers of specimens, both within and between laboratories, refer to Practice D 2906.

5.4 When a specified number of specimens are tested as directed in a method, the mean of the resulting observations is an *estimate* of the true average of the property being tested when measured as directed in the method. The larger the number of observations and the smaller the variability among the observations, the nearer the test result (the average of the observations) will tend to approach the true average.

NOTE 2—The term "true average" as used here refers to the average that would be obtained by testing the entire laboratory sampling unit as directed in the specified method.

5.5 The required number of specimens per unit of the laboratory sample is usually calculated using either Eq 2 or Eq 3 which are as follows:

$$k = (ts/E)^2 \quad (2)$$

$$k = (tv/A)^2 \quad (3)$$

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