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Standard Guide for Defining the Test Result of a Test Method[1]

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1. Scope

1.1 The purpose of this guide is to provide guidelines for identifying the elements that comprise the test result of a test method and to illustrate how these elements combine into the test result.

1.2 Types of measurement scales used for expressing observations and test results are discussed.

1.3 No system of units is specified in this standard.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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

E456 Terminology Relating to Quality and Statistics

2.2 *ISO Standard:*[3]

ISO 3534–2 Statistics—Vocabulary and Symbols, Part 2: Applied Statistics

3. Terminology

3.1 *Definitions*—For a more extensive list of terms in E11 standards, refer to Terminology E456.

3.1.1 *binary scale, n*—nominal scale with only two possible categories.

3.1.2 *characteristic, n*—a property of items in a sample or population which, when measured, counted or otherwise observed, helps to distinguish between the items.

3.1.3 *interval scale, n*—continuous scale or discrete scale with equal sized scale values and an arbitrary zero. **ISO 3534–2**

3.1.4 *nominal scale, n*—scale with unordered labeled categories or ordered by convention. **ISO 3534–2**

3.1.5 *observation, n*—the process of obtaining information regarding the presence or absence of an attribute of a test specimen, or of making a reading on a characteristic or dimension of a test specimen.

3.1.5.1 *Discussion*—Observation is also associated with the attribute or measurement information obtained from the process. The term "observed value" is preferred for this second usage.

3.1.6 *observed value, n*—the value obtained by making an observation.

3.1.7 *ordinal scale, n*—scale with ordered labeled categories. **ISO 3534–2**

3.1.8 *ratio scale, n*—continuous scale with equal sized scale values and an absolute or natural zero point. **ISO 3534–2**

3.1.8.1 *Discussion*—Ratio scales consist of only non-negative values.

3.1.9 *scale, n*—system of reference values for a characteristic. **ISO 3534–2**

3.1.10 *test determination, n*—the value of a characteristic or dimension of a single test specimen derived from one or more observed values.

3.1.11 *test method, n*—a definitive procedure that produces a test result.

3.1.11.1 *Discussion*—Examples of test methods include, but are not limited to: identification, measurement, and evaluation of one or more qualities, characteristics, or properties. **ASTM Regulations 2.2.6**

3.1.12 *test observation, n*—see *observation*.

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

3.1.13.1 *Discussion*—The test method specifies that one or a number of individual observations be made, and their average or another appropriate function, (such as the median or the standard deviation), be reported as the test result. It can also require standard corrections to be applied, such as correction of gas volumes to standard temperature and pressure. Thus, a test result can be a result calculated from several observed values. In the simple case, the test result is the observed value itself. **ISO 3534–2**

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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), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

3.1.14 *test specimen, n*—the portion of a test unit needed to obtain a single test determination.

3.1.14.1 *Discussion*—When used for a physical test, this is sometimes called "test piece." For a chemical test, it is sometimes called test portion or test sample. For optical and other tests, it is also sometimes called test sample. In interlaboratory evaluation of test methods and other statistical procedures, it is best to reserve the word sample for the whole amount of material involved and not the individual test specimens, pieces or portions being tested.

3.1.15 *test unit, n*—the total quantity of material (containing one or more test specimens) needed to obtain a test result as specified in the test method. (See *test result*.)

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *binary test result, n*—a test result for which the final value is one of two possible categories.

3.2.2 *ordinal test result, n*—a test result where the final value is reported as one of the scale results on an ordinal scale.

4. Significance and Use

4.1 All test methods have an output in the form of a test result. This guide provides information on the construction of test results from more elemental measurements.

4.2 A well defined test result is necessary before any precision statements can be made about the test method.

4.2.1 Form and Style for ASTM Standards, Section A21, requires that every test method shall contain a statement regarding its precision, preferably as a result of an interlaboratory test program. Reporting of such studies is described in Practice E177, which illustrates the development of test results from observations and test determinations.

4.2.2 Precision statements for ASTM test methods are applicable to test results. They are not applicable to test determinations or observations, unless specifically and clearly indicated otherwise.

5. Scales

5.1 The test method must clearly identify the scale for measuring the test observations and reporting the test results. Measurement scales are classified into various types. The primary classification is into numerical or categorical scales. Numerical scales, also known as quantitative scales, are established in terms of a defined numerical range with specified scale divisions. Categorical scales, also known as qualitative scales, are defined in terms of words, but the categories may be assigned numbers for purposes of data analysis.

5.2 Measurement scales may be sub-classified into a hierarchal system denoted as nominal, ordinal, interval, and ratio scales as follows:

5.2.1 A *nominal* scale is an unordered categorical scale. Examples include blood types (A, B, O) or categories of defect types.

5.2.1.1 A *binary* scale is the special case of a nominal scale with only two categories. An example is the presence or absence of some condition in a test specimen or in conducting a test method, such as a pipe or glass breaking after an impact, a cigarette igniting a piece of fabric, or a light bulb turning on.

5.2.2 An *ordinal* scale is an ordered categorical scale. An example is a rating scale comprising four categories: poor, fair, good, and excellent.

5.2.2.1 Worded categories may be assigned numbers, such as 1 = poor, 2 = fair, 3 = good, 4 = excellent.

5.2.2.2 The differences in categories, whether in numbers or labels, are not uniform and are often arbitrary or subjective.

5.2.3 An *interval* scale is a numeric scale with an arbitrary zero. Such scales may consist of negative and positive numbers, rounded to a defined number of significant figures. An example is the Celsius scale for temperature where 0°C is defined as the freezing point of water.

5.2.3.1 Differences are meaningful on an interval scale. A difference of 10 degrees Celsius is the same change in temperature throughout the scale.

5.2.4 A *ratio* scale is a numeric scale with an absolute zero, and all values are non-negative numbers. Examples are the length of an item or the temperature as measured on the Kelvin scale.

5.2.4.1 Ratios, as well as differences, are meaningful on a ratio scale.

5.3 *Other Types of Scales:*

5.3.1 A number of special types of scales may be constructed or utilized. These may involve non-linear scales such as logarithmic or power scales. Other situations may involve censored numerical responses where values that would be below a lower limit, or above an upper limit, are not reported numerically.

6. Developing the Test Result

6.1 A test method may have three distinct stages: (*1*) the direct measurement or observation of dimensions or properties, or the occurrence of an event; (*2*) the arithmetical combination of observed values to obtain a single determination; and (*3*) the arithmetical combination of a number of determinations to obtain the test result of a test method.

6.2 *Observation:*

6.2.1 An observation or observed value should be interpreted as the most elemental single reading or corrected reading obtained in the process of making a test or measurement.

6.2.2 An observation may be a classification into one of two categories or a numerical value on a continuous scale. An observation may involve a direct reading (for example, a zero-adjusted micrometer reading of the thickness of a test strip at one position along the strip) or it may require the interpolation of the reading from a calibration curve.

6.3 *Test Determination:*

6.3.1 For a quantitative test method, a test determination may be described as the process of calculating from one or more observations a property of a single test specimen, or as the value obtained from the process. Thus, a test determination may summarize or combine one or more observations.

6.3.2 For a qualitative test, such as a binary procedure, the test determination may be the total number of items falling into one of the two classifications following repetition of the basic protocol.

6.3.3 In some cases the protocol may require observations to be made under several test conditions and then calculating a test determination from these observations.

6.3.4 Test methods for chemical properties are often based on comparison of the response for a sample to responses of a known standard substance at varying concentrations. The standard curve relates response to concentration of the substance of interest. Responses belonging to the standard curve, and to test specimens, are test observations. The test determination is calculated from the response, or average of multiple responses, for the test specimen using an equation for the standard curve.

6.3.5 *Examples of a Test Determination:*

6.3.5.1 The measurement of the density of a test specimen may involve the separate observation of the mass and the volume of the specimen and the calculation of the ratio mass/volume. The density calculated from the ratio of one pair of mass and volume observations made on one specimen is a test determination.

6.3.5.2 The determination of the thickness of a test specimen strip may involve averaging micrometer caliper observations taken at several points along the strip.

6.3.5.3 A set of three cigarettes is ignited on a fabric. Each cigarette is observed to burn or not burn. The number of burns out of the set of three is a test determination.

6.4 *Test Result:*

6.4.1 In general, the test method should describe not only the manner in which each test determination is to be made, but also the number of test determinations to be made and how these are to be combined to provide the test result.

6.4.2 *Test Results Reported on Binary or Ordinal Scales:*

6.4.2.1 *Binary Test Results*—In some situations all observations, test determinations, and combinations of test determinations may lead to a final result that falls into one of two categories. See examples in 6.4.3.6 and 6.4.3.7.

6.4.2.2 *Ordinal Test Results*—In some situations the observations or test determinations initially reported on a quantitative scale are then reported on the basis of a series of ordinal scale values. See example in 6.4.3.8.

6.4.3 *Examples of a Test Result:*

6.4.3.1 The test method on density might require that the mass and volume observations of a specimen be combined to give a test determination of density (6.3.5.1) and the test determination of each of five specimens be averaged to give a test result.

6.4.3.2 The test method for paper thickness may require that the determination of strip thickness in 6.3.5.2 be made on ten strips and that the ten test determinations be averaged to give the test result.

6.4.3.3 The test method for a tensile strength test of paper may specify that a tensile strength determination be performed on each of ten specimens and that the ten tensile test determinations be averaged to get the test result.

6.4.3.4 In a chemical analysis, the method may call for the preparation of a single solution from the sample (test sample unit), and measurement on three aliquots (specimens) of the solution. The average of the three analytical test determinations would then be the test result. Alternatively, the method may call for test determinations to be made on different preparations (specimens) of the sample. The average of the determinations would then be the test result for the test sample

6.4.3.5 In rubber testing, the method may describe not only the shape of the test specimen to be taken from a sheet of rubber, but also the preparation of the sheet, including compounding and curing. For example, one rubber test method specifies that four sheets be individually compounded and cured and three specimens tested from each sheet. The test result is then defined as the average of the four medians, each median being the middle determination, in the order of magnitude, of the three values obtained from a sheet.

6.4.3.6 In examining for presence of cancer in a patient, a collection of different measurements might be obtained and the various test determinations combined to just report whether the individual has or does not have cancer. In this case, the test result is binary.

6.4.3.7 A collection of measurements on a product such as length, width, density, tensile strength, and number of defects present can be accumulated. The final test result could be to accept or reject. In this case, the test result is binary.

6.4.3.8 The total weight of a dozen eggs is measured on an ounce or gram scale. That weight is then converted to a scale ranging from small to jumbo, an ordinal scale.

7. Keywords

7.1 observation; test determination; test method; test result