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An American National Standard

Standard Terminology Relating to Quality and Statistics¹

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This standard has been approved for use by agencies of the Department of Defense.

ε¹ NOTE—E456 was updated editorially in February 2008.

1. Scope

1.1 This standard is the general terminology standard for terms defined in the standards of Committee E11 on Quality and Statistics.

1.2 A term in this standard which lists an attribution to an E11 technical standard indicates that the standard is normative for that term. Any changes in the term definition in the normative standard will be editorially changed in this standard. Any terms added to an E11 standard will be editorially added to this standard with an attribution to that standard.

1.3 Term definitions that are similar to **ISO 3534** will be noted in this standard, but **ISO 3534** will not be considered normative for any E11 terms.

2. Referenced Documents

2.1 *ASTM E11 Standards with terms in this standard:*²

E 29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E 178 Practice for Dealing With Outlying Observations

E 1169 Practice for Conducting Ruggedness Tests

E 1325 Terminology Relating to Design of Experiments

E 1488 Guide for Statistical Procedures to Use in Developing and Applying Test Methods

E 1994 Practice for Use of Process Oriented AOQL and LTPD Sampling Plans

E 2234 Practice for Sampling a Stream of Product by Attributes Indexed by AQL

E 2281 Practice for Process and Measurement Capability Indices

E 2282 Guide for Defining the Test Result of a Test Method

E 2334 Practice for Setting an Upper Confidence Bound For a Fraction or Number of Non-Conforming items, or a Rate of Occurrence for Non-conformities, Using Attribute Data, When There is a Zero Response in the Sample

E 2489 Practice for Statistical Analysis of One-Sample and Two-Sample Interlaboratory Proficiency Testing Programs

E 2554 Practice for Estimating and Monitoring the Uncertainty of Test Results of a Test Method in a Single Laboratory Using a Control Sample Program

E 2555 Practice for Factors and Procedures for Applying the MIL-STD-105 Plans in Life and Reliability Inspection

E 2586 Practice for Calculating and Using Basic Statistics

E 2587 Practice for Use of Control Charts in Statistical Process Control

2.2 *ISO Standards:*

ISO 3534 Statistics-Vocabulary and Symbols

Part 1: Probability and General Statistical Terms

Part 2: Applied Statistics

3. Terminology

acceptance (control chart or acceptance control chart usage,), *n*—a decision that the process is operating in a satisfactory manner with respect to the statistical measures being plotted: action limits: *control limits*.

acceptance quality limit AQL, *n*—quality limit that is the worst tolerable process average when a continuing series of lots is submitted for acceptance sampling. **E 2234**

accepted reference value, *n*—a value that serves as an agreed-upon reference for comparison, and which is derived as: (1) a theoretical or established value, based on scientific principles, (2) an assigned or certified value, based on experimental work of some national or international organization, or (3) a consensus or certified value, based on collaborative experimental work under the auspices of a scientific or engineering group. **E 177**

accuracy, *n*—the closeness of agreement between a test result and an accepted reference value. **E 177**

aliases, *n*—in a fractional factorial design, two or more effects which are estimated by the same contrast and which,

¹ This terminology is under the jurisdiction of ASTM Committee E11 on Quality and Statistics and is the direct responsibility of Subcommittee E11.70 on Editorial/Terminology.

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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.

- therefore, cannot be estimated separately. **E 1325**
- assignable cause**, *n*—factor that contributes to variation in a process or product output that is feasible to detect and identify (see special cause). **E 2587**
- attributes data**, *n*—observed values or test results that indicate the presence or absence of specific characteristics or counts of occurrences of events in time or space. **E 2587**
- attributes, method of**, *n*—measurement of quality by the method of attributes consists of noting the presence (or absence) of some characteristic or attribute in each of the units in the group under consideration, and counting how many units do (or do not) possess the quality attribute, or how many such events occur in the unit, group, or area. **E 2334**
- average outgoing quality (AOQ)**—the average percent defective of outgoing product including all accepted lots or batches, after any defective units found in them are replaced by acceptable units, plus all lots or batches which are not accepted after such lots or batches have been effectively 100 % inspected and all defective units replaced by acceptable units. **E 1994**
- average outgoing quality limit (AOQL)**—the maximum of the AOQs for all possible incoming percentages defective for the process, for a given acceptance sampling plan. **E 1994**
- average quality protection**—a type of protection in which there is prescribed some chosen value of average percent defective in the product after inspection (average outgoing quality limit (AOQL), that shall not be exceeded in the long run no matter what may be the level of percent defective in the product submitted to the inspector. **E 1994**
- average run length (ARL)**—the average number of times that a process will have been sampled and evaluated before a shift in process level is signaled. **E 2587**
- average standard deviation**, $\bar{s}$, *n*—arithmetic average of sample standard deviations. **E 2281**
- balanced incomplete block design (BIB)**, *n*—an incomplete block design in which each block contains the same number *k* of different versions from the *t* versions of a single principal factor arranged so that every pair of versions occurs together in the same number, λ , of blocks from the *b* blocks. **E 1325**
- batch**, *n*—a definite quantity of some product or material produced under conditions that are considered uniform.
- NOTE 1—A batch is usually smaller than a lot.
- batch, in inspection**, *n*—a collection of units of product produced under conditions that are considered uniform and from which a sample is drawn and inspected, and may differ from a collection of units designated as a batch for other purposes, for example, production, shipment, etc. **E 2234**
- batch size**, *n*—the number of units of product in a batch. **E 2234**
- bias**, *n*—the difference between the expectation of the test results and an accepted reference value. **E 177**
- c chart**—control chart that monitors the count of occurrences of an event in a defined increment of time or space. **E 2587**
- center line**—line on a control chart depicting the average level of the statistic being monitored. **E 2587**
- chance cause**—source of inherent random variation in a process which is predictable within statistical limits (see common cause). **E 2587**
- characteristic**, *n*—a property of items in a sample or population which, when measured, counted or otherwise observed, helps to distinguish between the items. **E 2282**
- check sample**—see **control sample**. **E 2554**
- classification of defects**, *n*—the enumeration of possible defects of the unit of product arranged according to their seriousness, that is, critical, major, or minor defect. **E 2234**
- cluster sampling**, *n*—when the primary sampling unit comprises a bundle of elementary units or a group of subunits, the term cluster sampling may be applied.
- DISCUSSION—Examples of cluster sampling are: selection of city blocks as primary sampling units; selection of a household as a cluster of people (of which only one may be interviewed); selection of bundles of rods or pipe from a shipment; and selection, from a shipment, of cartons that contain boxes or packages within them.
- coefficient of variation, CV**—for a nonnegative characteristic, the ratio of the standard deviation to the mean for a population or sample. **E 2586**
- collaborative study**, *n*—interlaboratory study in which each laboratory uses the defined method of analysis to analyze identical portions of homogeneous materials to assess the performance characteristics obtained for that method of analysis. **E 2489**
- collaborative trial**, *n*—see **collaborative study**. **E 2489**
- common cause**—see **chance cause**. **E 2587**
- completely randomized design**, *n*—a design in which the treatments are assigned at random to the full set of experimental units. **E 1325**
- completely randomized factorial design**, *n*—a factorial experiment (including all replications) run in a completely randomized design. **E 1325**
- component of variance**, *n*—a part of a total variance identified with a specified source of variability.
- composite design**, *n*—a design developed specifically for fitting second order response surfaces to study curvature, constructed by adding further selected treatments to those obtained from a 2^n factorial (or its fraction). **E 1325**
- confidence bound**, *n*—see **confidence limit**. **E 2334**
- confidence coefficient**, *n*—the value, *C*, of the probability associated with a confidence interval or statistical coverage interval. It is often expressed as a percentage. **ISO 3534-1** **E 2334**
- confidence level**, *n*—see **confidence coefficient**. **E 2334**
- confidence limit**, *n*—each of the limits, T_1 and T_2 , of the two sided confidence interval, or the limit *T* of the one sided confidence interval. **E 2334**
- confounded factorial design**, *n*—a factorial experiment in which only a fraction of the treatment combinations are run in each block and where the selection of the treatment combinations assigned to each block is arranged so that one or more prescribed effects is(are) confounded with the block effect(s), while the other effects remain free from confounding. **E 1325**

confounding, *n*—combining indistinguishably the main effect of a factor or a differential effect between factors (interactions) with the effect of other factor(s), block factor(s) or interactions(s). **E 1325**

consumer's risk—the probability that a lot whose percentage defective is equal to the LTPD will be accepted by the plan. **E 1994**

contrast, *n*—a linear function of the observations for which the sum of the coefficients is zero. **E 1325**

contrast analysis, *n*—a technique for estimating the parameters of a model and making hypothesis tests on preselected linear combinations of the treatments (contrasts). **E 1325**

control—(evaluation), *n*—an evaluation to check, test, or verify; (authority): the act of guiding, directing, or managing; (stability): a state of process in which the variability is attributable to a constant system of chance causes.

control chart, *n*—chart on which are plotted a statistical measure of a subgroup versus time of sampling along with limits based on the statistical distribution of that measure so as to indicate how much common, or chance, cause variation is inherent in the process or product. **E 2587**

control chart factor, *n*—a tabulated constant, depending on sample size, used to convert specified statistics or parameters into a central line value or control limit appropriate to the control chart. **E 2587**

control chart method, *n*—the method of using control charts to determine whether or not processes are in a stable state.

control limits, *n*—limits on a control chart that are used as criteria for signaling the need for action or judging whether a set of data does or does not indicate a state of statistical control based on a prescribed degree of risk. **E 2587**

control sample, *n*—sample taken from a stable, homogeneous material for the purposes of monitoring the performance of a test method in a laboratory. **E 2554**

critical defect, *n*—a defect that judgment and experience indicate would result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the product, or a defect that judgment and experience indicate is likely to prevent performance of the function of a major end item. **E 2234**

critical defective, *n*—a unit of product which contains one or more critical defects and may also contain major and/or minor defects. **E 2234**

defect, *n*—any nonconformance of the unit of product with specified requirements. **E 2234**

defective, *n*—a unit of product which contains one or more defects. **E 2234**

defects per hundred units, *n*—any given quantity of units of product is one hundred times the number of defects contained therein (one or more defects being possible in any unit of product) divided by the total number of units of product, that is:

$$\text{Defects per hundred units} = \frac{\text{Number of defects} \times 100}{\text{Number of units inspected}}$$

dependent variable, *n*—See **response variable**. **E 1325**

design of experiments, *n*—the arrangement in which an experimental program is to be conducted, and the selection

of the levels (versions) of one or more factors or factor combinations to be included in the experiment. Synonyms include experiment design and experimental design. **E 1325**

deviation, *n*—the difference between a measurement or quasi-measurement and its stated value or intended level.

DISCUSSION—*Deviation* should be stated as a difference in terms of the appropriate data units. Sometimes these units will be original measurement units; sometimes they will be quasi-measurements; that is, a scaled rating of subjective judgments; sometimes they will be designated values representing all continuous or discrete measurements falling in defined cells or classes.

double sampling plan, *n*—a multiple sampling plan in which up to two samplings can be taken and evaluated to accept or reject a lot. **E 2555**

empirical percentile, *n*—estimate of a population percentile using the sample data. This is a sample value such that a percentage *p* of the sample is less than that value. **E 2586**

error of result, *n*—the test result minus the accepted reference value (of the characteristic).

NOTE 2—It is not possible to correct for random error.

evolutionary operation (EVOP), *n*—a sequential form of experimentation conducted in production facilities during regular production. **E 1325**

experimental design, *n*—see **design of experiments**. **E 1325**

experiment space, *n*—the materials, equipment, environmental conditions and so forth that are available for conducting an experiment. **E 1325**

experimental unit, *n*—a portion of the experiment space to which a treatment is applied or assigned in the experiment. **E 1325**

factorial experiment (general), *n*—in general, an experiment in which all possible treatments formed from two or more factors, each being studied at two or more levels (versions) are examined so that interactions (differential effects) as well as main effects can be estimated. **E 1325**

2ⁿ factorial experiment, *n*—a factorial experiment in which *n* factors are studied, each of them in two levels (versions). **E 1325**

fractional factorial design, *n*—a factorial experiment in which only an adequately chosen fraction of the treatments required for the complete factorial experiment is selected to be run. **E 1325**

frame, *n*—a list, compiled for sampling purposes, which designates the items (units) of a population or universe to be considered in a study.

DISCUSSION—When a frame is available, sampling schemes can be devised for selection of the units directly (one-stage), or in two or more stages. In multi-stage sampling, a frame is needed for each stage. As an example, the cartons of a lot could be the first-stage units, packages within the carton could be second-stage units, and items within the packages could be the third-stage units.

fully nested experiment, *n*—a nested experiment in which the second factor is nested within levels (versions) of the first factor and each succeeding factor is nested within versions of the previous factor. **E 1325**

hierarchical experiment, *n*—see **nested experiment**.

- histogram**, *n*—graphical representation of the frequency distribution of a characteristic consisting of a set of rectangles with area proportional to the frequency. **E 2586**
- I chart**, *n*—control chart that monitors the individual subgroup observations. **E 2587**
- incomplete block design**, *n*—a design in which the experiment space is subdivided into blocks in which there are insufficient experimental units available to run a complete set of treatments or replicate of the experiment. **E 1325**
- inspection**, *n*—the process of measuring, examining, testing, or otherwise comparing the unit of product with the requirements. **E 2234**
- inspection by attributes**, *n*—inspection whereby either the unit of product is classified simply as defective or non-defective, or the number of defects in the unit of product is counted, with respect to a given requirement or set of requirements. **E 2234**
- interlaboratory comparison**, *n*—organization, performance, and evaluation of tests on the same or similar test items by two or more laboratories in accordance with predetermined conditions. **E 2489**
- interquartile range, IQR**, *n*—the 75th percentile (0.75 quantile) minus the 25th percentile (0.25 quantile), for a data set. **E 2586**
- intermediate precision**, *n*—the closeness of agreement between test results obtained under specified intermediate precision conditions. **E 177**
- intermediate precision conditions**, *n*—conditions under which test results are obtained with the same test method using test units or test specimens (see Practice E 691,² 10.3) taken at random from a single quantity of material that is as nearly homogeneous as possible, and with changing conditions such as operator, measuring equipment, location within the laboratory, and time. **E 177**
- item**, *n*—(1) an object or quantity of material on which a set of observations can be made: (2) an observed value or test result obtained from an object or quantity of material.
- DISCUSSION—The second usage in the definition is generally limited to generic descriptions such as in the definition of “population.” Terms such as “observation,” “measurement,” “test result,” “unit,” “value” or “yield” are more common in specific applications. A set as used here may be one or more variables.
- kurtosis**, γ_2 , g_2 , *n*—for a population or a sample, a measure of the weight of the tails of a distribution relative to the center, calculated as the ratio of the fourth central moment (empirical if a sample, theoretical if a population applies) to the standard deviation (sample, *s*, or population, σ) raised to the fourth power, minus 3 (also referred to as excess kurtosis). **E 2586**
- level (of a factor)**, *n*—a given value, a specification of procedure or a specific setting of a factor. **E 1325**
- limiting quality level (LQL)**, *n*—quality level having a specified consumer’s risk for a given sampling plan. **E 2555**
- long term standard deviation**, σ_{LT} , *n*—sample standard deviation of all individual (observed) values taken over a long period of time. **E 2281**
- lot**, *n*—see batch. **E 2234**
- lot size**, *n*—see batch size. **E 2234**
- lot quality protection**—a type of protection in which there is prescribed some chosen value of limiting percent defective in a lot (lot tolerance percent defective, (LTPD)) and also some chosen value for the probability (called the consumer’s risk) of accepting a submitted lot that has a percent defective equal to the lot tolerance percent defective. lot— lot size— **E 1994**
- lot tolerance percent defective (LTPD)**—the percentage of defective units in a batch or lot for which, for purposes of acceptance sampling, the consumer wishes the probability of acceptance to be restricted to a specified low value, specifically 10 % for this practice. This is also referred to by the more general term *limiting quality* taken at 10 % consumer risk. **E 1994**
- lower control limit (LCL)**, *n*—minimum value of the control chart statistic that indicates statistical control.. **E 2587**
- lower process capability index**, C_{pkl} , *n*—index describing process capability in relation to the lower specification limit. **E 2281**
- lower process performance index**, P_{pkl} , *n*—index describing process performance in relation to the lower specification limit. **E 2281**
- lower tolerance limit (LTL) (lower specification limit)**, *n*—a tolerance limit that defines the lower conformance boundary for an individual unit of a manufacturing or service operation.
- main effect, average effect**, *n*—a term describing a measure for the comparison of the responses at each level (version) of a factor averaged over all levels (versions) of other factors in the experiment. **E 1325**
- major defect**, *n*—a defect, other than critical, that is likely to result in failure, or to reduce materially the usability of the unit of product for its intended purpose. **E 2234**
- major defective**, *n*—a unit of product which contains one or more major defects, and may also contain minor defects but contains no critical defect. **E 2234**
- mean**, *n*—of a population, μ , average or expected value of a characteristic in a population – of a sample, $\bar{x}$ sum of the observed values in the sample divided by the sample size. **E 2586**
- median** $\tilde{X}$, *n*—the 50th percentile in a population or sample. **E 2587**
- method of least squares**, *n*—a technique of estimation of a parameter which minimizes $\sum e^2$, where *e* is the difference between the observed value and the predicted value derived from the assumed model. **E 1325**
- midrange**, *n*—average of the minimum and maximum values in a sample. **E 2586**
- minimum process capability index**, C_{pk} , *n*—smaller of the upper process capability index and the lower process capability index. **E 2281**
- minimum process performance index**, P_{pk} , *n*—smaller of the upper process performance index and the lower process performance index. **E 2281**
- minor defect**, *n*—a defect that is not likely to reduce materially the usability of the unit of product for its intended purpose,

or is a departure from established standards having little bearing on the effective use or operation of the unit.

E 2234

minor defective, *n*—a unit of product which contains one or more minor defects but contains no critical or major defect.

E 2234

mixture design, *n*—a design in which two or more ingredients or components shall be mixed and the response is a property of the resulting mixture that does not depend upon the amount of the mixture.

E 1325

MR chart, *n*—control chart that monitors the moving range of consecutive individual subgroup observations.

E 2587

multiple sampling plan, *n*—a sampling plan in which successive samples from a lot are drawn and after each sample is inspected a decision is made to accept the lot, reject the lot, or to take another sample, based on quality level of the combined samples.

E 2555

natural process limits (NPL), *n*—limits which include a stated fraction of the individuals in a population.

NOTE 3—*Natural process limits* will not ordinarily be the dimensional limits shown on an engineering drawing. They are mostly used to compare the natural capability of the process to tolerance limits.

DISCUSSION—For populations with a normal (Gaussian) distribution, the *natural process limits* ordinarily will be at $\pm 3\sigma$. If placed around the standard level, these limits identify the boundaries which will include approximately 99.7 % of the individuals in a process that is properly centered and in a state of *statistical control*. In many circumstances (several machines making the same product that serially feed into the process) it is recognized that in addition to the variability around a single level, an acceptable zone of “standard” levels (for the different machines) is required. Then the NPL may be placed around the Acceptable Process Levels (APL) that define this zone so that the NPL identify the boundaries within which at least 99.7 % of the individuals will be included in a process located at the APL, or inside the zone. It should be noted that there is no assumption made that the process levels within the zone are random variables.

nested experiment, *n*—an experiment to examine the effect of two or more factors in which the same level (version) of a factor cannot be used with all levels (versions) of other factors. Synonym: hierarchical experiment.

E 1325

non-conforming item, *n*—an item containing at least one non-conformity.

E 2334

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.

E 2282

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

E 2282

order statistic $x_{(k)}$, *n*—value of the k^{th} observed value in a sample after sorting by order of magnitude.

E 2586

orthogonal array, *n*—a table of coefficients identifying the levels, or some weight associated with the levels, for each factor to be used in the analysis of specified effects, which are arranged in such a manner that each effect will be independent of the other effects.

E 1325

orthogonal contrasts, *n*—two contrasts are orthogonal if the contrast coefficients of the two sets satisfy the condition that, when multiplied in corresponding pairs, the sum of the products is equal to zero. See **contrast** and **contrast analysis**.

E 1325

outlier—see **outlying observation**.

E 178

outlying observation, *n*—an observation that appears to deviate markedly in value from other members of the sample in which it appears.

E 178

p chart, *n*—control chart that monitors the fraction of occurrences of an event.

E 2587

partially balanced incomplete block design (PBIB), *n*—an incomplete block design in which each block contains the same number *k*, of different versions from the *t* versions of the principal factor.

E 1325

partially nested experiment, *n*—a nested experiment in which several factors may be crossed as in factorial experiments and other factors nested within the crossed combinations.

E 1325

percent defective, *n*—any given quantity of units of product one hundred times the number of defective units of product contained therein divided by the total number of units of product, that is:

$$\text{Percent Defective} = \frac{\text{Number of defectives} \times 100}{\text{Number of units inspected}}$$

E 2234

Plackett-Burman designs, *n*—a set of screening designs using orthogonal arrays that permit evaluation of the linear effects of up to $n = t - 1$ factors in a study of *t*, treatment combinations.

E 1325

population, *n*—the totality of items or units of material under consideration.

E 2586

population parameter, *n*—summary measure of the values of some characteristic of a population.

E 2586, ISO 3534-2

precision, *n*—the closeness of agreement between independent test results obtained under stipulated conditions.

E 177

probability sample, *n*—a sample of which the sampling units have been selected by a chance process such that, at each step of selection, a specified probability of selection can be attached to each sampling unit available for selection.

NOTE 4—These probabilities of selection need not be equal. If equal, see simple random sample. See the general term—sample. Also, see Practice E 105² in this volume.

process average, *in inspection*, *n*—the average percent defective or average number of defects per hundred units (whichever is applicable) of product submitted by the supplier for original inspection.

E 2234

process capability, *PC*, *n*—statistical estimate of the outcome of a characteristic from a process that has been demonstrated to be in a state of statistical control.

E 2281

process capability index, C_p , *n*—an index describing process capability in relation to specified tolerance.

E 2281

process performance, *PP*, *n*—statistical measure of the outcome of a characteristic from a process that may not have been demonstrated to be in a state of statistical control.

E 2281

process performance index, P_p , *n*—index describing process performance in relation to specified tolerance.

E 2281

quantile, *n*—value such that a fraction of the sample or population is less than or equal to that value.

E 2586

R chart, *n*—control chart that monitors the range of observations within a subgroup.

E 2587

proficiency testing, *n*—determination of laboratory testing

performance by means of interlaboratory comparisons.

E 2489

random error of result, *n*—a component of the error which, in the course of a number of test results for the same characteristic, varies in an unpredictable way.

randomization, *n*—the procedure used to allot treatments at random to the experimental units so as to provide a high degree of independence in the contributions of experimental error to estimates of treatment effects.

E 1325

randomized block design, *n*—a design in which the experiment space is subdivided into blocks of experimental units, the units within each block being more homogeneous than units in different blocks.

E 1325

randomized block factorial design, *n*—a factorial experiment run in a randomized block design in which each block includes a complete set of factorial combinations.

E 1325

range, *R*, *n*—maximum value minus the minimum value in a sample.

E 2586

rational subgroup, *n*—subgroup chosen to minimize the variability within subgroups and maximize the variability between subgroups (see **subgroup**).

E 2587

repeatability, *n*—precision under repeatability conditions.

E 177

repeatability conditions, *n*—conditions where independent test results are obtained with the same method on identical test items in the same laboratory by the same operator using the same equipment within short intervals of time.

E 177

repeatability limit *r*, *n*—the value below which the absolute difference between two individual test results obtained under repeatability conditions may be expected to occur with a probability of approximately 0.95 (95 %).

E 177

repeatability standard deviation (*s_r*, *n*—the standard deviation of test results obtained under repeatability conditions.

E 177

reproducibility, *n*—precision under reproducibility conditions.

E 177

reproducibility conditions, *n*—conditions where test results are obtained with the same method on identical test items in different laboratories with different operators using different equipment.

E 177

reproducibility limit, *R*, *n*—the value below which the absolute difference between two test results obtained under reproducibility conditions may be expected to occur with a probability of approximately 0.95 (95 %).

E 177

reproducibility standard deviation *s_R*, *n*—the standard deviation of test results obtained under reproducibility conditions.

E 177

residual error, *n*—the difference between the observed result and the predicted value (estimated treatment response); Observed Result minus Predicted Value.

E 1325

response surface, *n*—the pattern of predicted responses based on the empirical model derived from the experiment observations.

E 1325

response variable, *n*—the variable that shows the observed results of an experimental treatment. Synonym dependent variable.

E 1325

robustness, *n*—insensitivity of a statistical test to departures from underlying assumptions.

DISCUSSION—Many statistical test procedures depend on the form of the assumed distribution of the population sampled to obtain exact values for the probability statements. If departures from the assumed distribution do not materially affect the decisions which would be based on the statistical tests involved, the test is considered “robust.” For example, tests based on an assumption of normality that compare averages generally are robust even though the underlying distribution of individual items in the population is not normal. On the other hand, the F-statistic for comparing variances may be an indicator of lack of normality rather than a simple variance comparison.

ruggedness, *n*—insensitivity of a test method to departures from specified test or environmental conditions.

E 1169

ruggedness test, *n*—a planned experiment in which environmental factors or test conditions are deliberately varied in order to evaluate the effects of such variation.

E 1169

run, *n*—(1) an uninterrupted sequence of occurrences of the same attribute or event in a series of observations, and (2) a consecutive set of successively increasing run-up or successively decreasing run-down values in a series of variable measurements.

DISCUSSION—In control chart applications, some variable measurements are treated as attributes in determining runs. For example, a run might be considered a series of a specified number of consecutive points above or below the central line.³

s chart, *n*—control chart that monitors the standard deviations of subgroup observations.

E 2587

sample, *n*—a group of observations or test results, taken from a larger collection of observations or test results, which serves to provide information that may be used as a basis for making a decision concerning the larger collection.

E 2586

sample size, *n*—number of observed values in the sample.

E 2586

sample size code letter, *n*—a device used along with the AQL for locating a sampling plan on a table of sampling plans.

E 2234

sample statistic, *n*—summary measure of the observed values of a sample.

E 2586

sampling fraction, *f*, *n*—the ratio *f* of the number of sampling units selected for the sample to the number of sampling units available.

NOTE 5—For the simple random sample case, $f = n/N$ where *n* is the sample size and *N* is the number of sampling units available. When $f > 0.10$ estimation of the precision of an estimator should take account of this magnitude of *f*. See finite population correction.

sampling plan, in inspection, *n*—a plan that indicates the number of units of product from each lot or batch which are to be inspected (sample size or series of sample sizes) and the criteria for determining the acceptability of the lot or batch (acceptance and rejection numbers).

E 2234

sampling with replacement, *n*—a procedure used with some probability sampling plans in which a selected unit is replaced after any step in selection so that this sampling unit is available for selection again at the *next* step of selection,

³ Other examples may be found in references such as Nelson, L. S., “Interpreting Shewhart $\bar{X}$ Control Charts,” *Journal of Quality Technology*, Vol 17, No. 2, April 1985.

or at any other succeeding step of the sample selection procedure.

screening design, *n*—a balanced design, requiring relatively minimal amount of experimentation, to evaluate the lower order effects of a relatively large number of factors in terms of contributions to variability or in terms of estimates of parameters for a model. **E 1325**

short term standard deviation, σ_{ST} , *n*—the inherent variation present when a process is operating in a state of statistical control, expressed in terms of standard deviation. **E 2281**

significant digit, *n*—any of the figures 0 through 9, except leading zeros and some trailing zeros, which is used with its place value to denote a numerical quantity to some desired approximation. **E 29**

skewness γ_1 , g_1 , *n*—for population or sample, a measure of symmetry of a distribution, calculated as the ratio of the third central moment (empirical if a sample, and theoretical if a population applies) to the standard deviation (sample, *s*, or population, σ) raised to the third power. **E 2586**

special cause, *n*—see **assignable cause**. **E 2587**

specification limits, *n*—see **tolerance limits**. **E11.30**

stable process, *n*—process in a state of statistical control; process condition when all special causes of variation have been removed. **ISO 3534-2** **E 2281**

staggered nested experiment, *n*—a nested experiment in which the nested factors are run within only a subset of the versions of the first or succeeding factors. **E 1325**

standard deviation, *n*—of a population, σ , the square root of the average or expected value of the squared deviation of a variable from its mean — of a sample, *s*, the square root of the sum of the squared deviations of the observed values in the sample divided by the sample size minus 1. **E 2586**

state of statistical control, *n*—process condition when only common causes are operating on the process. **E 2587**

statistic, *n*—a quantity calculated from a sample of observations, most often to form an estimate of some population parameter.

statistical measure, *n*—statistic or mathematical function of a statistic.

DISCUSSION—The word *statistical* emphasizes that measures are subject to inherent errors and that, in estimating a population parameter, they represent a sample, with inherent sampling variability.

statistical procedures, *n*—the organized techniques and methods used to collect, analyze, and interpret data. **E 1488**

statistical process control (SPC), *n*—set of techniques for improving the quality of process output by reducing variability through the use of one or more control charts and a corrective action strategy used to bring the process back into a state of statistical control. **E 2587**

subgroup, *n*—set of observations on outputs sampled from a process at a particular time. **E 2587**

systematic error of result, *n*—a component of the error, which in the course of a number of test results for the same characteristic, remains constant or varies in a predictable way.

NOTE 6—Systematic errors and their causes may be known or unknown.

systematic sampling, *n*—sample selection procedure in which every *k*th element is selected from the universe or population; for example, *u*, *u* + *k*, *u* + 2*k*, *u* + 3*k*, etc., where *u* is in the interval 1 to *k*.

DISCUSSION—If *k* = 20 and *u* = 7 is the initial unit selected, then sampling units 7, 27, 47, 67, ..., would comprise the sample. When *N/k* is not an integer, there is a small bias due to the end effect. When *u* is selected by a chance process and *N/k* is an integer, the systematic sample will provide unbiased estimates of the population average or total. Situations for which *N/k* is not an integer usually ignore the small or negligible bias in estimating the mean or total. Schemes have been developed for non-integer *N/k* to overcome sampling bias. See Jessen.⁴

Estimation of the precision of an average computed from a systematic sample is a difficult problem that has no generally satisfactory solution. Independent replicate systematic samples provide an approach to variance estimation, but have been rejected by some writers. In some ASTM situations where replicate samples may be obtained on a routine basis, the technique may be useful. See Cochran⁵ for an extended discussion of variance estimation for systematic sampling.

test determination, *n*—the value of a characteristic or dimension of a single test specimen derived from one or more observed values. **E 2282**

test method, *n*—a definitive procedure that produces a test result. **E 2282**

test observation, *n*—see **observation**. **E 2282**

test result, *n*—the value of a characteristic obtained by carrying out a specified test method. **E 2282**

test specimen, *n*—the portion of a test unit needed to obtain a single test determination. **E 2282**

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*. **E 2282**

tolerance limits (specification limits), *n*—limits that define the conformance boundaries for an individual unit of a manufacturing or service operation.

DISCUSSION—Limits may be established either with or without the use of probability considerations. *Tolerance limits* may be in the form of a single (unilateral) limit (upper or lower) or double (bilateral) limits (upper and lower). Double, or two-sided limits occur more frequently. Double limits are often stated as a symmetrical deviation from a stated value, but they need not be symmetrical. Frequently the term *specification limits* is used instead of *tolerance limits*. While *tolerance limits* is generally preferred in terms of evaluating the manufacturing or service requirements, *specification limits* may be more appropriate for categorizing material, product, or service in terms of their stated requirements.

tolerance specification, *n*—the total allowable variation around a level or state (upper limit minus lower limit), or the maximum acceptable excursion of a characteristic.

DISCUSSION—The determination of the amount of variation to be allowed involves the product or service requirements and consideration of process capability (see **natural process limits**), measurement variability, and other appropriate elements or some compromise among these.

⁴ Jessen, R. J., "Statistical Survey Techniques," John Wiley & Sons, Inc., New York, 1978, Sec. 12.2.

⁵ Cochran, W. G., "Sampling Techniques," John Wiley & Sons, Inc., New York, 1977, Chapter 8.

treatment, *n*—a combination of the levels (versions) of each of the factors assigned to an experimental unit, synonym **treatment combination.** E 1325

treatment combination, *n*—see **treatment.** E 1325

trueness, *n*—the closeness of agreement between the population mean of the measurements or test results and the accepted reference value. E 177

uncertainty, *n*—an indication of the variability associated with a measured value that takes into account two major components of error: (1) bias, and (2) the random error attributed to the imprecision of the measurement process.

DISCUSSION—Quantitative measures of uncertainty generally require descriptive statements of explanation because of differing traditions of usage and because of differing circumstances. For example: (1) the bias and imprecision may both be negligible; (2) the bias may not be negligible while the imprecision is negligible; (3) neither the bias nor the imprecision may be negligible; (4) the bias may be negligible while the imprecision is not negligible.

uncertainty control chart, *n*—control chart that includes control limits based on the variation attributed to the uncertainty of the test method. E 2554

unit, *n*—an object on which a measurement or observation may be made.

DISCUSSION—The word “unit” is commonly used in the sense of a *unit of product* (service, etc.)—the entity of product inspected in order to determine its classification or its measurements. This entity may be a single article, a set of like articles treated collectively, a subassembly, a stated quantity of material, etc. The unit of product or service need not be the same as the unit of purchase, supply, production, or shipment.

unit of product, *n*—that which is inspected in order to determine its classification as defective or non-defective or to count the number of defects. E 2234

universe (population), *n*—the totality of the set of items, units, or measurements, etc., real or conceptual, that is under consideration.

NOTE 7—This definition of universe is being revised to incorporate the concept of including one or more populations. *Use with caution.*

upper control limit (UCL), *n*—maximum value of the control chart statistic that indicates statistical control. E 2587

upper process capability index, C_{pkU} , *n*—index describing process capability in relation to the upper specification limit. E 2281

upper process performance index P_{pkU} , *n*—index describing process performance in relation to the upper specification limit. E 2281

upper tolerance limit (UTL) (upper specification limit), *n*—a tolerance limit applicable to the upper conformance boundary for an individual unit of a manufacturing or service operation.

variables, method of, *n*—measurement of quality by the method of variables consists of measuring and recording the numerical magnitude of a quality characteristic for each of the units in the group under consideration.

NOTE 8—This involves reference to a continuous scale of some kind.

variables data, *n*—observations or test results defined on a continuous scale. E 2587

variance, σ^2, s^2 , *n*—square of the standard deviation of the population or sample. E 2586

warning limits, *n*—limits on a control chart that are two standard errors below and above the centerline. E 2587

within-laboratory standard deviation, *n*—the standard deviation of test results obtained within a laboratory for a single material under conditions that may include such elements as different operators, equipment, and longer time intervals. E 177

X-bar chart, *n*—control chart that monitors the average of observations within a subgroup. E 2587

Youden square, *n*—a type of block design derived from certain Latin squares by deleting, or adding, rows (or columns) so that one block factor remains complete blocks and the second block factor constitutes balanced incomplete blocks. E 1325

Z-score, *n*—observed value minus the sample mean divided by the sample standard deviation. E 2586

4. Keywords

acceptance sampling terminology, quality control terminology, sampling terminology, specifications terminology, statistics terminology.

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