Designation: E 456 – 04$^{\epsilon 1}$

An American National Standard

Standard Terminology Relating to Quality and Statistics[1]

This standard is issued under the fixed designation E 456; 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.

ϵ^1 NOTE—Editorial changes were made throughout in February 2006.

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 Guide for Conducting Ruggedness Tests
E 1325 Terminology Relating to Design of Experiments
E 1402 Terminology Relating to Sampling
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 Indexedby 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

2.2 *ISO Standards:*

ISO 3534 Statistics-Vocabulary and Symbols
Part 1: Probability and General Statistical Terms
Part 2: Applied Statistics
Part 3: Design of Experiments

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, therefore, cannot be estimated separately. **E 1325**

assignable cause, *n*—a factor that contributes to variation, and which is feasible to detect and identify.

NOTE 1—Many factors will contribute to variation but it may not be feasible (economically or otherwise) to identify some of them.

[1] This terminology is under the jurisdiction of ASTM Committee E 11 on Quality and Statistics and is the direct responsibility of Subcommittee E11.70 on Editorial/Terminology.

Current edition approved Nov. 1, 2004. Published December 2004. Originallyapproved in 1972. Last previous edition approved in 2002 as E 456 – 02.

[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.

attribute data, *n*—observed values or determinations which indicate the presence or absence of specific characteristics.

DISCUSSION—Items or units of material may be evaluated by counting or measurement. Attributes are counted whereas variables are measured. Attribute distributions are discrete. See **variables data**.

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)—(*1*) **sample sense,** *n*—the average number of times that a process will have been sampled and evaluated before a shift in process level is signaled, and (*2*) **unit sense,** *n*—the average number of units that will have been produced before a shift in level is signaled.

DISCUSSION—A long ARL is desirable for a process located at its specified level (so as to minimize calling for unneeded investigation or corrective action) and a short ARL is desirable for a process shifted to some undesirable level (so that corrective action will be called for promptly). ARL curves are used to describe the relative quickness in detecting level shifts of various control chart systems.

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 2—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**

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**

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.

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 factor, *n*—a factor, usually varying with sample size, to convert specified statistics or parameters into a central line value or control limit appropriate to the control chart.

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 which are used as criteria for signaling the need for action, or for judging whether a set of data does or does not indicate a state of statistical control.

NOTE 3—Frequently, a number of results of measurements of a quantity is used to establish a conventional true value.

conventional true value of a quantity, *n*—value attributed to a particular quantity and accepted, sometimes by convention, as having an uncertainty appropriate for a given purpose.

NOTE 4—′′Conventional true value" is sometimes called ′′assigned value", ′′best value", ′′conventional value", or ′′reference value". ′′Reference value", in this sense, should not be confused with ′′reference value" in the sense of an influence quantity affecting a measuring instrument.

DISCUSSION—When warning limits are used, the control limits are often called "action limits." Action may be in the form of investigation of the source(s) of an "assignable cause", making a process adjustment, or terminating a process. Criteria other than *control limits* are also used frequently.

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:

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

E 2234

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.

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

NOTE 5—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**

2^n 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**. **E 1325**

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 nondefective, or the number of defects in the unit of product is counted, with respect to a given requirement or set of requirements. **E 2234**

intermediate precisions, *n*—the closeness of agreement between test results obtained under specified intermediate precision conditions.

NOTE 6—The specific measure and the specific conditions must be specified for each intermediate measure of precision; thus, ″standard deviation of test results among operators in a laboratory,″ or ″day-to-day standard deviation within a laboratory for the same operator.″

NOTE 7—Because the training of operators, the agreement of different pieces of equipment in the same laboratory and the variation of environmental conditions with longer time intervals all depend on the degree of within-laboratory control, the intermediate measures of precision are likely to vary appreciably from laboratory to laboratory. Thus, intermediate precisions may be more characteristic of individual laboratories than of the test method. **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.

level (of a factor), *n*—a given value, a specification of procedure or a specific setting of a factor. **E 1325**

long term standard deviation, σ_{LT}, *n*—sample standard deviation of all individual (observed) values taken over a long period of time.

DISCUSSION—A long period of time may be defined as shifts, weeks, or months, etc. **E 2281**

lot—a definite quantity of a product or material accumulated under conditions that are considered uniform for sampling purposes.

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. **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*—control limit for points below the central line.

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**

method of least squares, *n*—a technique of estimation of a parameter which minimizes Σe^2, where e is the difference between the observed value and the predicted value derived from the assumed model. **E 1325**

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**

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

NOTE 8—*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