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STANDARD STATISTICAL VOCABULARY AND SYMBOLS

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BUREAU OF CEYLON STANDARDS

STANDARD STATISTICAL VOCABULARY AND SYMBOLS

S.L.S. 421 : 1977

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SRI LANKA STANDARD STATISTICAL VOCABULARY AND SYMBOLS

FOREWORD

This Sri Lanka Standard Vocabulary and Symbols has been prepared by the Drafting Committee of the Bureau on Statistics and Quality Control. It was authorised for adoption and publication by the Council of the Bureau on 1977-05-11.

With greater recognition of the importance of statistical techniques in quality control work, it has now become necessary to introduce more and more statistical techniques into this field and also to facilitate the application of the techniques which are already in use. It was for this reason that the Bureau recently set up a Drafting Committee on Statistics and Quality Control and entrusted the same with the function of formulating statistical and quality control standards. The Committee has already prepared/adopted a series of standards including those on Random Sampling Methods, Statistical Interpretation of Data, and Sampling Procedures and Tables for Inspection by Attributes, some of which are due for submission to the Council of the Bureau for approval.

During the committee discussions it was found necessary that the statistical terms used in these documents should also be standardised so as to introduce their meanings and also to avoid possible confusions in using them. This Sri Lanka Standard Vocabulary and Symbols is the result of the Committee's efforts towards achieving this aim.

The assistance derived from the publications of the International Organisation for Standardization (ISO R 645 and ISO R 1786) and the Standards Association of Australia in the preparation of this standards is gratefully acknowledged.

SCOPE

The aim of this Sri Lanka Standard is to define some statistical terms which may be useful in other Sri Lanka Standards.

Part 1 of this standard is divided into five sections :

(1) General terms,

(2) Terms used in calculation of probability,

(3) Terms used in sampling,

(4) General Statistical terms.

(5) Terms relating to sampling inspection,

Part 2 gives a list of statistical symbols.

PART 1

STATISTICAL VOCABULARY

1. GENERAL TERMS

1.1 Batch, Lot — A definite quantity of some commodity manufactured or produced under conditions which are presumed uniform.

1.2 Consignment — A quantity of some commodity delivered at one time. The consignment may consist of one or more batches or parts of batches.

1.3 Order — A quantity of a commodity ordered at one time from one producer. An order may consist of one or more consignments.

1.4 Item

(a) An actual or conventional object on which a set of observations may be made, or

(b) A defined quantity of material, on which a set of observations may be made, or

(c) An observed value, either qualitative or quantitative.

Note: The English terms " individual " and " unit " are sometimes used as synonyms of " item ".

1.5 Population — The totality of items under consideration.

1.6 Characteristic — A property which helps to differentiate between the items of a given population. The differentiation may be either quantitative (by variables) or qualitative (by attributes).

1.7 Test — An operation made in order to measure or classify a characteristic.

1.8 Observed Value— The value of a characteristic determined as a result of an observation or test.

1.9 Absolute Difference— The absolute value of the difference between two values.

1.10 Specification — An accurate statement of a set of requirements to be satisfied by a product, a material or a process, indicating, whenever appropriate, the procedure by means of which it may be determined whether the given requirements are satisfied.

Note 1. A specification may be a standard, a part of a standard, or independent of a standard.

Note 2. As far as practicable, it is desirable that the requirements are expressed numerically in terms of appropriate units together with their limits.

2. TERMS USED IN CALCULATION OF PROBABILITY

2.1 Random Variable ; Variate — A variable which may take any of the values of a specified set of values and to which is associated a probability distribution (see Clause 2.2).

A random variable which may take only isolated values is said to be " discrete ". A random variable which may take all the values of a finite or infinite interval is said to be " continuous ".

2.2 Probability Distribution of a Random Variable — A distribution which determines the probability that a random variable takes any given value or belongs to a given set of values. The probability on the whole interval of variation of the variable equals 1.

2.3 Distribution Function — A function giving, for every value x, the probability that the value of the random variable X be lower than or equal to x.

$$F(x)=Pr\,[\,X \leqslant x\,]$$

2.4 Probability Density Function for a Continuous Random Variable — The derivative (when it exists) of the distribution function.

$$f(x) = \frac{d\,F(x)}{dx}$$

Note : f(x) dx is the " probability element ".

$$f(x)\,d\,x = Pr\,[\,x < X < x + d\,x\,]$$

2.5 Probability for a Discrete Random Variable — x_i being one of the values which can be taken by the discrete random variable X, the probability p_i is

$$P_i = Pr\,[X = x_1\,]$$

2.6 Fractile (or Quantile) of a Probability Distribution — In the case of a continuous variable, the fractile of order p of the random variable X is a number x_p such that

$$\Pr[\,X \leqslant x_p\,] = p_1,\ 0 < p < 1$$

x_p is the abscissa of the point of ordinate p in the graph representing the distribution function.

In the case of a discrete variable, the fractile is uniquely determined by the above relation only if x_p is one of the values that the random variable can take.

2.7 Expectation (mean) of a Random Variable — For a discrete random variable X taking the values x_i with the probability p_i, the expectation is defined by

$$E(X) = \Sigma\, p_i x_i$$

the sum being extended for all the values x_i which can be taken by X.

For a continuous random variable X having the density f(x), the expectation is defined by

$$E\,(X) = \int x\, f(x)\, dx$$

the integral being extended for all values of the interval of variation of X.

2.8 Centred Random Variable — A random variable the expectation of which equals zero.

Note : If the random variable X has an expectation equal to m, the corresponding centred variable is the variable X − m.

2.9 Variance (of a Random Variable) — The expectation of the square of the centred variable.

2.10 Standard Deviation (of a Random Variable) — The positive square root of the variance.

2.11 Standardized Variate — A random variable the expectation of which equals zero and the standard deviation of which equals 1.

Note : If the random variable X has an expectation equal to m and a standard deviation equal to σ, the corresponding standardized variate is the variable.

$$\frac{X - m}{\sigma}$$

The distribution of the standardized variate is called " standardized distribution ".

2.12 Coefficient of Variation (of a Random Variable) — The ratio of the standard deviation to the absolute value of the expectation of the random variable.

2.13 Mode — The value (s) of a random variable such that the probability (discrete variable) or the density (continuous variable) has a maximum for this value (or these values). If there is one mode, the probability distribution of the variable is said to be " unimodal ", in the other case, it is said to be " multimodal " (bimodal if there are two modes).

2.14 Binomial Distribution — The probability distribution of a discrete random variable X such that, if x is one of the integral values 0, 1, 2 . . . n, the distribution is

$$\Pr\left[X=x\right] = \binom{n}{x} p^{x} (1 - p)^{n-x} ; \quad \binom{n}{x} = \frac{n!}{x!\,(n-x)!}$$

$$0 \leq p \leq 1$$

Note : When in a series of n independent trials, the probability or realization of an event E is constant and equal to p at each trial, the probability that for the n given trials, the event occurs x times (x = 0. 1, 2 . . . n), is given by the binomial distribution. For instance if a lot contains a great number or items with a proportion defective p, a simple random sample of n items from the lot may contain 0, 1, 2 . . . n, defectives and the probabilities associated with these events are given with a good approximation by the binomial distribution having the parameter p, on the condition that the sample size is small with regard to the lot size.

The binomial distribution may be strictly applied only in the case of n items taken with replacement.

2.15 Negative Binomial Distribution — The probability distribution of a discrete random variable X such that, if **x** is one of the whole values c, c +1, . . . (x $\geq$ c), the distribution is

$$\Pr [X=x] = \binom{x-1}{c-1} p^c (1-p)^{x-c}$$

$$0 \leqslant p \leqslant 1$$

Note : When in a series of n independent trials, the probability or realization of an event E is constant and equal to p at each trial, the probability that the c^{th} realization of E (c being now a fixed positive integral value) occurs for the x^{th} trial (x = c, c + 1, c + 2 . . .) is given by the negative binomial distribution.

2.16 Poisson Distribution— The probability distribution of a discrete random variable X such that, if x is one of the whole values 0, 1, 2, ... the distribution is

$$\Pr [X = x] = e^{-m} \frac{m^x}{x!}$$

where e is the base of natural logarithms and m is a positive parameter.

Note : The expectation and the variance of the Poisson distribution are both equal to m.

2.17 Hypergeometric Distribution— The probability distribution of a discrete random variable X which can take whole values such that the distribution is

$$\Pr [X = x] = \frac{\binom{d}{x}\binom{N-d}{n-x}}{\binom{N}{n}}$$

The whole values x should satisfy the relations :

$$\left.\begin{array}{r} 0 \leqslant x \leqslant n \\ x \leqslant d \end{array}\right\} n - N + d \leqslant x \leqslant d$$
$$n - x \leqslant N - d$$

Note 1 : In a population containing N items, with d having a particular property (for instance a lot of N items contains d defectives) a sample of size n is taken without replacement. The probability that this sample contains x items having the considered property (x defectives) is given by the expression of the hypergeometric distribution.

Note 2 : In the formula, n and d can be transposed. The probability of getting x defectives in a sample taken from a population of N items is therefore the same when the sample contains n items and the population d defectives, as when the sample contains d items and the population n defectives.

2.18 Normal (or Laplace - Gauss) Distribution — The probability distribution of a continuous random variable X such that, if x is any real number, the probability density is

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{x-m}{\sigma}\right)^2\right]$$

$$-\infty < x < +\infty$$

Note : m is the expectation and σ is the standard deviation of the normal distribution ($\sigma > 0$).

2.19 Standardized Normal Distribution — The probability distribution of a normal variable when its expectation is taken as origin and its standard deviation as unit. For a normal variable X having m and σ as parameters, the standardized random variable is

$$U = \frac{X - m}{\sigma}$$

and the probability density is

$$f(u) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right)$$

$$-\infty < u < +\infty$$

2.20 Chi-squared Distribution — The distribution of the sum of squares of independent standardized normal variables. The number of these variables is the number ν of degrees of freedom of the χ^2 distributed variable, a parameter of the distribution.

Note : The mathematical expression is as follows :

$$F(\chi^2, v) = \frac{(\chi^2)^{\frac{v}{2}-1}}{2^{\frac{v}{2}}\,\Gamma\left(\frac{v}{2}\right)} \exp\left(-\frac{\chi^2}{2}\right)$$

2.21 t - (or Student) Distribution— The distribution of a quotient of independent variables, the numerator of which is a normal standardized variable, and the denominator of which is the positive square root of the quotient of a χ^2 distributed variable by its number of degrees of freedom. The number of degrees of freedom of χ^2 is the number ν of degrees of freedom of the t-distributed variable.

Note : The mathematical expression is as follows :

$$f(t, v) = \frac{1}{\sqrt{\pi v}} \, \frac{\Gamma\left(\frac{v+1}{2}\right)}{\Gamma\left(\frac{v}{2}\right)} \, \frac{1}{\left(1+\frac{t^2}{v}\right)^{\frac{v+1}{2}}}$$

2.22 F - Distribution— The distribution of the quotient between two independent χ^2 distributed variables, each one divided by its number of degrees of freedom. The numbers of degrees of freedom of the χ^2 distributed variables of the numerator v_1 and of the denominator v_2 are, in this order, the numbers of degrees of freedom of the F-distributed variable.

Note : The mathematical expression is as follows :

$$f(F, v_1, v_2) = \frac{\Gamma\left(\frac{v_1+v_2}{2}\right)}{\Gamma\left(\frac{v_1}{2}\right)\Gamma\left(\frac{v_2}{2}\right)} (v_1)^{\frac{v_1}{2}} (v_2)^{\frac{v_2}{2}} \frac{F^{\frac{v_1-2}{2}}}{(v_1F+v_2)^{\frac{v_1+v_2}{2}}}$$

2.23 Log - Normal Distribution — The probability distribution of a continuous random variable X which can take any value from a to infinity, with the probability density.

$$f(x) = \frac{1}{(x-a)\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\log_e(x-a)-m}{\sigma}\right)^2\right]$$

Note 1 : The probability distribution of the variable log (X-a) is a normal distribution ; m and σ are respectively the expectation and the standard deviation of this variable.

Note 2 : The $\log_{10}$ is often used instead of the $\log_e$.

2.24 Exponential Distribution — The probability distribution of a continuous random variable X which can take any value from 0 to $+\infty$, with the probability density

$$f(x) = \lambda e^{-\lambda x} \qquad \lambda > 0$$

This probability distribution may be generalized by substituting x - a for x (with $x \geqslant a$).

2.25 Gamma Distribution — The probability distribution of a continuous random variable X which can take any value from 0 to $+\infty$ with the probability density

$$f(x) = \frac{e^{-x} \; x^{m-1}}{\Gamma(m)}$$

with $m > 0$

and $$\Gamma(m) = \int_0^\infty e^{-x} x^{m-1} \, dx$$

m, a positive constant, determines the form of the distribution. When m is a whole number, we have

$$\Gamma(m) = (m-1)!$$

For m = 1 the gamma distribution becomes the exponential ($\lambda = 1$) distribution.

This probability distribution may be generalized by substituting $\frac{x - a}{b}$ for x (with $x \geq a$ and $b > 0$).

2.26 Gumbel Distribution (or Double Exponential Distribution)— The probability distribution of a continuous random variable X, the distribution function of which is defined by

$$F(x) = \exp(-e^{-y}) \quad \text{with } y = \frac{x - a}{b}, \; b > 0,$$

$$-\infty < x < +\infty, \; -\infty < a < +\infty$$

2.27 Frechet Distribution — The probability distribution of a continuous random variable X, the distribution function of which is defined by

$$F(x) = \exp(-y^{-k}) \text{ with } y = \frac{x - a}{b}, \; b > 0, \; x \geq a,$$

$$-\infty < a < +\infty$$

k, a positive constant, determines the form of the distribution.

2.28 Weibull Distribution — The probability distribution of a continuous random variable X, the distribution function of which is defined by

$$F(x) = 1 - \exp(-y^{k}) \text{ with } y = \frac{x - a}{b}, \; b > 0, \; x \geq a,$$

$$-\infty < a < +\infty$$

k, a positive constant, determines the form of the distribution.

3. TERMS USED IN SAMPLING

3.1 Sample — One or more items taken from a population and intended to provide information on the population and possibly to serve as a basis for a decision on the population or on the process which had produced it.

Note : The sampling of bulk materials, of discrete populations and of continuous materials such as sheet metal, etc., requires the use of terms specific to their nature. In the sampling of solid bulk materials (powders, coal, coke, etc.) the words " increment ", " gross sample ", " laboratory sample " and " test sample " are used while the word " specimen " is used in connection with the sampling of discrete populations. The word " test piece " is used in connection with sampling of continuous material such as sheet metal.

3.2 **Increment** — A quantity of material acquired at one time from a larger body of material. A number of such increments will usually form a sample.

Note : The English word " increment " is not applied to liquids.

3.3 **Gross Sample** — A sample as collected.

3.4 **Laboratory Sample** — A sample as prepared for sending to the laboratory.

3.5 **Test Sample** — A sample as prepared for testing.

3.6 **Test Piece** — A part obtained from an increment or from a specimen for the purpose of testing.

3.7 **Sampling Fraction** — The ratio between the size of a simple sample and the size of the population, or sub-population, in which it has been taken.

3.8 **Sample Preparation** — For bulk materials, the set of material operations such as reduction of sizes, mixing, dividing, etc. necessary to transform a gross sample into a laboratory or test sample.

Note : The sample preparation should not, as far as possible, modify its representativity of the sampled lot.

3.9 **Replicated Sample** — A sample obtained by sampling, in which the items to be taken are divided in n sub-samples of equal sizes which are prepared and tested separately. The total number of items to be taken should be, in this case, a multiple of the number of the sub-samples.

3.10 **Duplicated Sample** — A replicated sample containing only two sub -samples.

3.11 **Simple Random Sampling** — A type of sampling in which a sample of n items is drawn from a population of N items in such a way that all possible combinations of n items have the same probability of being chosen.

3.12 **Stratified Sampling** — Of a population which can be divided according to criteria depending on cases into different sub-populations (called strata), sampling carried out in such a way that specified proportions of the sample are drawn from different strata.

3.13 **Systematic Sampling** — A type of sampling in which N items in a population are numbered 1 to N on a systematic basis (for example in order of production) and a sample of n items is constituted by taking the items numbered h, h + k, h + 2k, ... h + (n – 1) k, where h and k are whole numbers satisfying the relation

$$h + (n - 1) \leqslant N < h + nk, \quad h \text{ being}$$

generally taken at random from the first k whole numbers.

3.14 **Cluster Sampling** — The population is divided into aggregates (or clusters) of sampling units bound together in a certain manner. A sample of these clusters is taken at random and all the sampling units which constitute them are included in the sample.

Note : Multi-stage cluster sampling
Cluster sampling with more than two stages can also be considered, each sampling being made on aggregates (or clusters) in which the clusters already obtained by the preceding sampling have been divided.

3.15 **Multi-stage Sampling** — A type of sampling in which the sample is selected by stages, the sampling units at each stage being sub-sampled from the larger units chosen at the previous stage.

4. GENERAL STATISTICAL TERMS

4.1 **Class** — In the case of measurable characteristics, each of the consecutive intervals into which the total interval of variation is grouped.

4.2 Class Limits — The values defining the upper and lower bounds of a class.

Note : It should be specified which of the two limits is considered as belonging to the class.

4.3 Mid-point of Class — The arithmetic mean of the upper and lower limits of a class.

4.4 Size (or Absolute Frequency) — Number of items (of a population, batch, sample, class, etc.)

4.5 Relative Frequency — The ratio of the number of times a particular value (or a value falling within a given class interval) is observed to the total number of observations.

4.6 Frequency Distribution — The relationship between the values of a characteristic and their absolute or relative frequencies. The distribution is often presented as a table with special groupings (class intervals) if the values are measured on a continuous scale.

4.7 Cumulative Absolute Frequency — In the case of measurable characteristics, the number of items the values of which are lower than or equal to a given value, or lower than or equal to the upper limit of a given class.

4.8 Cumulative Relative Frequency — In the case of measurable characteristics, the relative frequency of items the values of which are lower than or equal to a given value or lower than or equal to the upper limit of a given class.

4.9 Cumulative Absolute (or Relative) Frequency Polygon — The polygonal line obtained by joining the points the abscissa of which is the value of the variable or the upper limit of each class and the ordinate of which is the cumulative absolute (or relative) frequency.

4.10 Histogram — A presentation of the frequency distribution by means of a line bordering the rectangles obtained by representing on a horizontal axis, with a linear scale, the class limits of the values of the characteristic and by drawing rectangles whose base is each class interval and whose area is proportional to the class frequency.

4.11 Population Parameter — A quantity which helps to describe the distribution of a population.

4.12 Statistic — A function of the observed values derived from a sample.

4.13 Estimation, Estimate (of Parameters)

(a) **Estimation** — The operation made for the purpose of assigning from the values observed on a sample, numerical values to the parameters of a distribution chosen as the mathematical model of the population from which this sample is taken.

(b) **Estimator** — A combination of the sample values used in estimation.

(c) **Estimate** — The numerical result of this operation in a specific case.

This result may be expressed either as a single numerical value (point estimate) or as a confidence interval.

4.14 Tolerance Zone — The zone of values in which a measurable characteristic is in conformity with its specification.

4.15 Tolerance Limits — The limit value (lower or upper) specified for a measurable characteristic. When there is one specified limit, it is called " single tolerance limit ". When there are two limits, upper and lower, they are respectively called " upper tolerance limit " and " lower tolerance limit ".

4.16 Tolerance — The difference between the upper and lower tolerance limits.

4.17 Unbiased Estimator — An estimator T of a parameter (θ) such that the expectation of T equals (θ).

$$E(T) = (\theta)$$

4.18 Arithmetic Mean — Sum of the observed values divided by their number.

4.19 Weighted Average

(a) A non-negative number called weight being assigned to each of the observed values, the weighted average is equal to the sum of the products of each value by its weight, divided by the sum of the weights.

(b) **Weighted Variance**

A non-negative number called weight being assigned to each of the squares of the deviations of the observed values from the arithmetic mean, the weighted variance is equal to the sum of the product of each of the squares of the deviations of the observed values from the arithmetic mean by it's weight, divided by the sum of the weights.

4.20 Median — Of n observed values arranged in order of magnitude and numbered 1 to n, the median of these n observed values is the $\frac{(n+1)}{2}$ th value, if n is odd.

If n is even, the median is undefined ; unless otherwise specified, it may be taken to be the arithmetic mean of the $\frac{n}{2}$ th and $(\frac{n}{2}+1)$ th values.

4.21 Mean Deviation — The mean deviation from an origin is the arithmetic mean of the deviations from that origin when all deviations are given a positive sign.

Note : Unless otherwise specified, the origin is the arithmetic mean.

4.22 Sample Variance— The arithmetic mean of the squares of the deviations from the arithmetic mean.

4.23 Sample Standard Deviation — The positive square root of the variance.

4.24 Coefficient of Variation (of a Set of Observed Values) — The ratio of the standard deviation to the absolute value of the arithmetic mean expressed as a percentage.

Note : The above ratio is referred to as the relative error.

4.25 Standard Error — The standard deviation of an estimator, the standard error provides an estimation of the random part of the error involved in estimating a population parameter from a sample.

4.26 Range — The difference between the greatest and the smallest observed values of a measurable characteristic.

4.27 Mid-range— The arithmetic mean of the greatest and the smallest observed values of a measurable characteristic.

4.28 Estimation of the Mean of a Population — The operation made for the purpose of estimating the mean $\overline{X}$ of a population considered as representing the population.

Note : The arithmetic mean $\overline{x}$ of a simple random sample of size n taken from that population is an unbiased estimator of $\overline{X}$ or m.

4.29 Estimation of the Variance of a Population — The operation made for the purpose of estimating the variance Λ^2 of a population considered as representing this population.

Note 1 : In the case of a simple random sample of size, n, an unbiased estimator of the variance is obtained by dividing by n – 1 the sum of squares of the deviations of the observed values from the arithmetic mean of this sample.

Note 2 : Distribution : The positive square root of the unbiased estimator of the variance is often used as an estimator of the standard deviation. However, it ought to be noted that this estimator is not unbiased.

4.30 Confidence Interval — When it is possible to define two functions T_1 and T_2 of the observed values such that, θ being a population parameter to be estimated the probability.

$$P\,[T_1 \leqslant \theta \leqslant T_2] = 1 - \alpha$$

where $1 - \alpha$ is a fixed number, positive and less than 1, the interval between T_1 and T_2 is a confidence interval for θ.

The limits T_1 and T_2 of the confidence interval are random variables and as such may assume different values in every sample.

In a long series of samples, the relative frequency of cases where the interval includes θ would be approximately equal to $1 - \alpha$.

4.31 One-sided Confidence Interval — When it is possible to define a function T of the observed values, such that, (θ) being a population parameter to be estimated, the probability Pr $[T \geqslant (\theta)]$ or the probability Pr $[T \leqslant (\theta)]$ is equal to $1 - \alpha$ (where $1 - \alpha$ is some fixed number, positive and less than 1), the interval from the smallest possible value of (θ) up to T, or the interval between T and the greatest possible value of (θ), is a one-sided confidence interval for (θ).

The limit T of the confidence interval is a random variable and as such may assume different values in every sample.

In a long series of samples, the relative frequency of cases where the interval includes (θ) would be approximately equal to $1 - \alpha$.

4.32 Confidence Coefficient, Confidence Level — The value $1 - \alpha$ of the probability associated with a given confidence interval.

4.33 Confidence Limit — The values T_1 and T_2 which form the lower and upper limits to the confidence interval.

4.34 Accuracy of the Mean — Closeness of agreement between the true value and the mean result which would be obtained by applying the experimental procedure a very large number of times.

The procedure is the more accurate as the systematic part of the experimental errors which affect the results is smaller.

4.35 Precision — Closeness of agreement between the results obtained by applying the experimental procedure several times under prescribed conditions.

The smaller the random part of the experimental errors, the more precise is the procedure.

4.36 Repeatability — Closeness of agreement between successive results obtained with the same method on identical test material and under the same conditions (same operator, same apparatus, same laboratory and same time).

4.37 Reproducibility — Closeness of agreement between individual results obtained with the same method on identical test material but under different conditions (different operators, different apparatus, different laboratories and/or different times).

Note : If the terms 4.34 to 4.37 are used with other meanings than those given above, the terms should be specially and precisely defined, as experience has shown that ambiguities can arise.

4.38 Likelihood — The probability of obtaining some set of observed values, when it is supposed that these are obtained independently from each other from the same specified distribution.

4.39 Statistical Test — A procedure based on a function (called "statistic") of the values observed on one or more samples and leading to rejection or not to rejection, with some risks of error (see Clauses 4.40 and 4.42), a hypothesis generally called "null hypothesis" relating to the sampled population(s).

Examples : Test of the hypothesis that the mean m of the population from which a sample has been taken equals a specified number m (null hypothesis $m - m_0 = 0$).

Test of the equality between the means m_1 and m_2 of the populations from which two samples have been taken (null hypothesis $m_1 - m_0 = 0$).

Test of the hypothesis that the lot percent defective p is not greater than a given value p_1 (null hypothesis $p - p_1 \leqslant 0$).

4.40 Error of First Kind — The error made in rejecting the null hypothesis when it is true. The probability of committing such an error, provided the null hypothesis is true, is called risk of first kind. The maximum value of this risk (upper bound) is the level of significance α.

Note : For instance, with the null hypothesis $p - p_1$, the upper bound of this risk in most tests is obtained for $p = p_1$.

4.41 Alternative Hypothesis — An hypothesis which is used when null hypothesis is rejected.

Examples : Test of the null hypothesis $m - m_0 = 0$ (m = mean of the population from which a sample has been taken, m_0 = specified number) against the alternative hypothesis $m - m_0 > 0$.

Test of the null hypothesis $m - m_0 = 0$ against the alternative hypothesis $m - m_0 \neq 0$.

4.42 Error of Second Kind — The error made in not rejecting the null hypothesis when it is false. The probability of committing such an error depends on the actual state, which can be characterized by the value of one or several parameters. It is called risk of second kind.β

4.43 Power of the Test — The complement to 1 of the risk of second kind $(1 - \beta)$ is named " power of the test ".

4.44 Two-sided Test — A test in which the null hypothesis is rejected if the specified statistic takes a value outside a finite specified interval.

If the interval is chosen in such a way that the probability of rejection, when the null hypothesis is true, is equally divided on both sides of this interval, then the test is called " symmetrical ".

4.45 One-sided Test — A test in which the null hypothesis is rejected if the specified statistic takes a value less (or greater) than a given number.

4.46 Operating Characteristic Curve of a Test (OC Curve) — When the actual state is characterized by one value of the set of possible values of a parameter, the operating characteristic curve of the test shows the probability of no-rejection of the null hypothesis for the different possible value of the parameter used in the test.

Example : Test of the hypothesis that the mean m of a normal population the variance of which is known equals a specified value m_0.

n items are taken at random from the population ; the arithmetic mean $\overline{x}$ of the characteristic under consideration is computed for this sample.

Besides, a number L (which is, in the present case, independent of the observed results) is determined ; if $\overline{x}$ falls in the interval $m_0 \pm L$, the hypothesis is not rejected ; in the other case, it is rejected.

The operating characteristic curve of this test shows, as a function of the possible values of the mean m of the population, the probability not to reject the hypothesis $m = m$ that is to say, the probability that the mean $\overline{x}$ falls in the interval $m_0 \pm L$. For

$m = m_0$, the ordinate of the operating characteristic curve equals $1 - \alpha$, α being the risk of first kind (level of significance) associated to the null hypothesis $m = m_0$. For any value $m_1 \neq m_0$, the ordinate of the curve equals β, the risk of second kind associated to the alternative hypothesis $m = m_1$.

Note : The operating characteristic curve of a test is also called " Power function of the test ".

4.47 **t (Student) — Test** — A test in which the statistic used has a t-(Student) distribution occurring, for instance, in the following problems :

— test of the equality between the mean of a normal population and a specified value based on the mean observed on a sample taken from this population, the variance of the population being estimated from these samples ;

— test of the equality between the means of two normal populations having the same variance based on the means observed on two independent samples taken from these populations, the common variance being estimated from these samples ;

— test of a linear regression coefficient.

4.48 **F-Test** — A test in which the statistic used has an F-distribution, occurring for instance in the following problems :

— test of the equality of the variances of two normal populations based on the variances estimated from two independent samples taken from these populations ;

— test occurring in the analysis of variance.

4.49 **Chi-squared Test** — A test in which the statistic used has a χ^2 distribution, occurring for instance in the following problems :

— test of the equality between the variance of a normal population and a specified variance, based on the variance estimated from a sample taken from this population ;

— comparison between the observed sizes and the theoretical sizes corresponding to a distribution specified in advance or defined from observed values ;

— tests of independence and of homogeneity.

5. TERMS RELATING TO SAMPLING INSPECTION

5.1 Quality Control

(a) In the wider sense : the set of operations (programming, co-ordinating, carrying out) intended to maintain or to improve quality, and to set up the production at the most economical level which allows for customer satisfaction.

5.2 Statistical Quality Control — Quality control using statistical methods (such as control charts sampling plans etc.)

5.3 Acceptance — The consent to take a lot as offered.

5.4 Rejection — The refusal to take a lot as offered.

Note : When it is applied to the consignment of a producer, the term " rejection " means in a more liberal sense " non acceptance " of the lot under the conditions of the contract (e.g. the lot may be brought into another class, put through a lowering of price, etc.)

5.5 Sampling Plan — A plan according to which one or more samples are taken in order to obtain information and to reach a decision.

5.6 Acceptance Sampling Plan — A sampling plan intended for determining the acceptance or the rejection of a lot.

5.7 100% Inspection — Inspection of all the items or of the whole material in a batch.

5.8 Sampling Inspection — The inspection of a limited number of units, or of a limited quantity of material, taken at random from the lot or process according to a prescribed sampling plan.

5.9 Lot Inspection, Acceptance Inspection

(a) Lot inspection : the inspection carried out on a lot once an operation of production is finished, for example before passing from one production operation to another. The inspection carried out when the whole of the production operation is finished is called " final inspection ".

(b) Acceptance inspection : the inspection of delivered products, carried out by a consumer.

5.10 Original Inspection — The term "original" applies to lots submitted to inspection for the first time, in order to distinguish them from lots which are to be re-submitted.

Note : As a matter of fact, when a lot has been rejected, the producer may be authorised to re-submit this lot after it has been modified in order to improve its quality (screening inspection, repairing etc.).

5.11 Single Sampling — A type of sampling which consists in taking only one sample on which a decision is made.

5.12 Double Sampling — A type of sampling which consists in taking possibly a second sample according to the information given by the first.

5.13 Multiple Sampling — A type of sampling which consists in taking possibly up to k successive samples, the decision on taking the i-th sample ($i \leqslant k$) being dependent on the information given by the ($i - 1$) previous samples.

5.14 Sequential Sampling — A type of sampling which consists in taking successive items, or sometimes successive groups of items, but without fixing their number in advance, the decision to accept or reject the batch being taken as soon as the results permit it, according to a rule laid down in advance.

5.15 Defect — A failure of an item to meet a standard with respect to one or more specified characteristics.

5.16 Critical Defect — A defect that, according to judgment and experience, is likely to result in hazardous or unsafe conditions for individuals using, maintaining, or depending upon the considered product, or that is likely to prevent performance of the function of a major end item.

5.17 Major Defect — A defect, other than critical, that is likely to result in a failure, or to reduce materially the usability of the considered product for its intended purpose.

5.18 Minor Defect — A defect that is not likely to reduce materially the usability of the considered product for its intended purpose, to that is a departure from established specifications having little bearing on the effective use or operation of this product.

5.19 Defective, Defective Item — An item containing one or more defects.

5.20 Critical Defective — An item which contains one or more major defects ; it may also contain major or minor defects.

5.21 Major Defective — An item which containing one or more major defects ; it may also contain minor defects but no critical defect.

5.22 Minor Defective — An item which contains one or more minor defects ; it contains no critical or major defect.

5.23 Mean Number of Defects per Unit — The number of defects observed on a given size divided by this size. Multiplied by 100, it gives the " mean number of defects per 100 units ".

5.24 Fraction Defective — The number of defective items divided by the total number of items. Multiplied by 100, the fraction defective gives the " percentage defective ".

5.25 Process Average — The average quality of production estimated from successive samples taken from the production process.

5.26 Method by Attributes — A method of estimating the quality which consists in taking note, for every item of a population or of a sample taken from this population, of the presence or the absence of a certain qualitative characteristic (attribute) and in counting how many items have or do not have this characteristic.

5.27 Method by Defect-counting — A method of estimating the quality which consists in counting, over the items of a population or over a sample taken from this population, the number of defects per item or for 100 items.

5.28 Method by Variables — A method of estimating the quality in which certain quality characteristics of the sample are evaluated with respect to a continuous numerical scale and expressed as precise points along this scale. The method records the degree of conformance or non-conformance of the item with specified requirements for the quality characteristic involved.

5.29 Acceptance Number — The greatest value of the number of defects or defectives found in the sample which involves the acceptance of the lot in a sampling inspection by attributes.

Note : In sampling by variables, other acceptance or rejection numbers may be defined in terms of the observed values and the permitted tolerances.

5.30 Rejection Number — The lowest value of the number of defects or defectives found in the sample which involves the rejection of the lot, in a sampling inspection by attributes.

5.31 Probability of Acceptance — The probability that a lot of a given quality will be accepted by a given sampling plan.

5.32 Probability of Rejection — The probability that a lot of a given quality will be rejected by a given sampling plan.

5.33 Curtailed Inspection — In the case of simple or multiple sampling, an inspection stopped as soon as the decision (acceptance or rejection) may be taken.

In the case of sequential sampling, an inspection stopped according to a rule laid down in advance, though the decision of acceptance or rejection could not be taken ; then this decision is taken according to a rule also laid-down in advance.

5.34 Inspection Level — A characteristic of a sampling plan, chosen in advance and connecting the size of the sample (s) to the lot size.

5.35 Normal Inspection — The inspection which is used when there is no reason to think that the quality level of the production differs from the level provided for.

5.36 Reduced Inspection — The inspection, less severe than the normal inspection, to which it is passed when the inspection results of a number of lots allow the belief that the quality level of the production is high.

5.37 Tightened Inspection — The inspection, more severe than the normal inspection, to which it is passed when the inspection results of a number of lots allow the belief that the quality level of the production is poor.

5.38 Operating Characteristic Curve (OCC) — A curve showing, for a given sampling plan, the probability of acceptance of a batch as a function of its actual quality.

5.39 Producer's Risk — For a given sampling plan, the probability of rejection of a batch whose defective proportion has a value stated by the plan.

5.40 Consumer's Risk — For a given sampling plan, the probability of acceptance of a batch whose defective proportion has a value stated by the plan. (This value is evidently greater than the one relating to a producer's risk).

5.41 Acceptable Quality Level — A quality level which in a sampling plan corresponds to a specified but relatively high probability of acceptance.

5.42 Lot Tolerance per cent Defective — A quality level which in a sampling plan corresponds to a specified but relatively low probability of acceptance.

5.43 Point of Control (of the Operating Characteristic Curve) — The point of the operating characteristic curve corresponding to probabilities of acceptance and rejection equal to 0.50.

5.44 Quality Limit — The quality of a lot, or a series of lots, settled by any authority or by agreement between producer and consumer, to be regarded as the lowest quality acceptable.

5.45 Average Outgoing Quality (AOQ) — The average quality expressed in percentage defectives or in number of defects per 100 items, of the product obtained after inspection, including not only batches accepted by the plan but also batches rejected by the plan which have been given 100% inspection and all defectives replaced by non-defectives.

5.46 Average Outgoing Quality Limit (AOQL) — The maximum value of the average outgoing quality.

5.47 Average Sample Number — For a given sampling plan, the average number of inspected items, expressed as a function of the actual quality.

5.48 Assignable Cause — A cause of systematic variation identifiable by statistical methods.

5.49 Process under Control — A process the mean and variability of which remain within specified limits.

5.50 Control Chart — A chart on which limits are drawn and on which are plotted values of any statistic computed from successive samples of a production. The control chart is used to investigate if a process may be considered under control.

The statistics which are used (mean, range, percentage, defective etc.) define the different kinds of control charts.

5.51 Upper and/or Lower Control Limits — In a control chart, the limit below which (upper limit) or above which (lower limit), or the limits between which the statistic under consideration is with a very high probability when the process is under control. When the value of the statistic computed from a sample is above the upper limit or below the lower limit, a corrective action should generally be made on the process of production.

5.52 Upper and/or Lower Warning Limits — In a control chart, the limit below which (upper limit) or above which (lower limit) or the limits between which the statistic under consideration is with a high probability when the process is under control. When the value of the statistic computed from a sample is outside the warning limits but inside the control limits an increased supervision of the process of production is generally necessary.

PART II
STATISTICAL SYMBOLS

X	Random variable, variate, value observable on a characteristic, in a population
x	particular value
k	class number
N	population or lot size
n	sample size
f	relative frequency, for a sample
w	range of a sample
X	arithmetic mean for a population
$\overline{x}$	arithmetic mean for a sample

σ^2	variance of a random variable or of a population
σ	standard deviation of a random variable or of a population
s^2	variance of a sample
s	standard deviation of a sample
	Note : The symbol s^2 is also often used to designate the sum of the squares of the deviations from the arithmetic mean, divided by $n - 1$ (and the symbol s for the square root of this quantity).
$(\sigma^2)^*$ or $\hat{\sigma}$	estimator of the variance σ^2
σ^* or $\hat{\sigma}$	estimator of σ
P or **Pr**	probability
P (E) or Pr (E)	probability of an event **E**
x_p	fractile of order p of the random variable **X**
E (X)	expectation of a random variable. In some cases, m is used to designate the expectation.
U	standard normal variable
ν	number of degrees of freedom
χ^2	shows both the random variable and a particular value of this variable
	Note : If necessary, the following symbols should be used :
	χ^2_α — fractile of order α of the χ^2 variable
	$\chi^2(\nu)$ — χ^2 variable with ν degrees of freedom
	$\chi^2_\alpha(\nu)$ — fractile of order α of the χ^2 variable with ν degrees of freedom.

t shows both the random variable and a particular value of this variable

Note : If necessary, the following symbols should be used :

t_α — fractile of order α of the t variable

$t(\nu)$ — t variable with ν degrees of freedom

$t_\alpha(\nu)$ — fractile of order α of the t variable with ν degrees of freedom

F shows both the random variable and a particular value of this variable

Note : If necessary, the following symbols should be used :

F_α — fractile of order α of the F variable

$F(\nu_1,\nu_2)$ — F variable with ν_1 and ν_2 degrees of freedom

$F_\alpha(\nu_1,\nu_2)$ — fractile of order α of the F variable with ν_1 and ν_2 degrees of freedom

Note : If necessary, indices may be added to symbols.

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