Glossary

additivity A concept relating to the independence of factors. The effect of additive factors occurs in the same direction (i.e., they do not interact).

adjusting factor A signal factor used to adjust the output.

analysis of variance (ANOVA) Analysis of the impacts of variances caused by factors. ANOVA is performed after the decomposition of the total sum of squares.

array A table of rows and columns used to make the combinations of an experiment.

base space A normal group selected by specialists to construct Mahalanobis space.

CAMPS Computer-aided measurement and process design and control system.

classified attribute The type of quality characteristic that is divided into discrete classes rather than being measured on a continuous scale.

compounding of noise factors A strategy for reducing the number of experimental runs by combining noise factors into a single output for experimentation.

confirmation experiment A follow-up experiment run under the conditions defined as optimum by a previous experiment. The confirmation experiment is intended to verify the experimental predictions.

confounding A condition in which experimental information on variables cannot be separated. The information becomes intermingled with other information.

control factor A product or process parameter whose values can be selected and controlled by the design or manufacturing engineer.

data analysis The process performed to determine the best factor levels for reducing variability and adjusting the average response toward the target value.

decomposition of variation The decomposition of collected data into the sources of variation.

degrees of freedom The number of independent squares associated with a given factor (usually, the number of factor levels minus 1).

design of experiments Experimental and analysis methods to construct mathematical models related to the response to the variables.

direct product design A layout designed to determine the interaction between any control factor assigned to an orthogonal array and any noise factor assigned to the outer array.

distribution A way of describing the output of a common-cause system variation in which individual values are not predictable but in which the outcomes as a group form a pattern that can be described in terms of its location, spread, and shape. Location is commonly expressed by the terms of the mean or median, and spread is commonly expressed in terms of the standard deviation or the range of a sample. Shape involves many characteristics, such as symmetry and peakedness. These are often summarized by using the name of a common distribution, such as the normal, binomial, or Poisson.

downstream quality Also called customer quality, such as car noise, vibration, or product life. It is the type of quality easily noticed by the customer. This is the type of quality to avoid using for quality improvement.

dummy treatment A method used to modify an orthogonal array to accommodate a factor with fewer levels.

dynamic characteristic A characteristic that expresses the functionality, transformation, and adjustability of the output of a system or subsystem.

dynamic operating window The gap between the total reaction rate and the side-reaction rate in chemical reactions. The greater the gap, the more desirable the result.

environmental noise factors Sources of variability due to environmental conditions when a product is used.

error sums of squares The total of the sums of squares that are considered as residual.

expected value of a variance The mean of an infinite number of variances estimated from collected data.

factor A parameter or variable that may affect product or process performance.

factorial effect The effect of a factor or an interaction or both.

feedforward control A way to compensate for the variability in a process or product by checking noise factor levels and sending signals that change an adjustment factor.

finite element method A computer-aided method used in many areas of engineering and physics to determine an approximate solution to problems that are continuous in nature, such as in the study of stress, strain, heat transfer, or electrical fields.

fractional factorial layout An experimental design that consists of a fraction of all factor-level combinations.

generic function The relationship between the objective output and the means as the signal that engineers use in order to generate the objective output.

go/no-go specifications The traditional approach to quality, which states that a specification part, component, or assembly that lies between upper and lower specifications meets quality standards.

hi–low table A table showing the magnitude of effects in descending order.

ideal function The ideal relationship under the standard condition between output and the signal by the users.

indicative factor A factor that has a technical meaning but has nothing to do with the selection of the best level.

inner array A layout or orthogonal array for the control factors selected for experimentation or simulation.

interaction A condition in which the impact of a factor or factors on a quality characteristic changes depending on the level of another factor (i.e., the interdependent effect of effect of two or more factors).

larger-the-better characteristic The type of performance parameter that gives improved characteristic performance as the value *of* the parameter increases (e.g., tensile strength, power, etc.) This type of characteristic belongs to the category of quality characteristics that has infinity as the ideal value and has no negative value.

least squares method A method to express the results by a function causes using existing data in such a way that the residual error of the function is minimized.

linear equation The equation showing the case when the input/output regression line does not pass through the origin.

linearity A measure of the straightness of a response plot. Also the extent to which a measuring instrument's response is proportional to the measured quantity.

loss function *See* quality loss function.

Mahalanobis distance A statistical tool introduced by P. C. Mahalanobis in 1930 to distinguish the pattern of one group from others.

Mahalanobis–Gram–Schmidt process (MTGS) One of the processes used to compute a Mahalanobis distance.

Mahalanobis space (MS) A normal space, such as a healthy group in a medical study.

Mahalanobis–Taguchi system (MTS) A measuring method of recognizing patterns using a Mahalanobis distance.

manufacturing tolerance The assessment of tolerance prior to shipping. The tolerance manufacturing tolerance is usually tighter than the consumer tolerance.

mean The average value of some variable.

mean-squared deviation (MSD) A measure of variability around the mean or target value.

mean-squared error variance The variance considered as the error.

mean sum of squares The sum of squares per unit degree of freedom.

measurement accuracy The difference between the average result of a measurement with a particular instrument and the true value of the quantity being measured.

measurement error The difference between the actual value and measured value of a measured quantity.

measurement precision The extent to which a repeated measurement gives the same result. Variations may arise from the inherent capabilities of the instrument, from changes in operating condition, and so on. *See also* repeatability *and* reproducibility.

midstream quality Also called *specified quality,* such as dimension or specification. This is the type of quality to avoid using for quality improvement.

multiple correlation Correlation by multiple variables.

noise factor Any uncontrollable factor that causes product quality to vary. There are three types of noise: (1) noise due to external causes (e.g., temperature,

humidity, operator, vibration, etc.); (2) noise due to internal causes (e.g., wear, deterioration, etc.); and (3) noise due to part-to-part or product-to-product variation.

nominal-the-best characteristic The type of performance characteristic parameter that has an attainable target or nominal value (e.g., length, voltage, etc.).

nondynamic operating window A gap between the maximum and the minimum functional limits. A wide gap means a more robust function.

number of units The total of the square of the coefficients in a linear equation. It is used to calculate the sum of squares.

objective function The relationship between the objective characteristic and the signal used by the users.

off-line quality control Activities that use design of experiments or simulation to optimize product and process designs. These activities include system design, parameter design, and tolerance design.

on-line quality control Activities that occur at the manufacturing phase and include use of the quality loss function to determine the optimum inspection interval, control limits, and so on. On-line quality control is used to maintain the optimization gained through off-line quality control.

origin quality Also called *functional quality*. This is the type of quality used to improve the robustness of product functions.

orthogonal array A matrix of numbers arranged in rows and columns in such a way that each pair of columns is orthogonal to each other. When used in an experiment, each row represents the state of the factors in a given experiment. Each column represents a specific factor or condition that can be changed from experiment to experiment. The array is called orthogonal because the effects of the various factors in the experimental results can be separated from each other.

orthogonal polynomial equation An equation using orthogonal polynomial expansion.

outer array A layout or orthogonal array for the noise factors selected for experimentation.

parameter design The second of three design stages. During parameter design, the nominal values of critical dimensions and characteristics are established to optimize performance at low cost.

P-diagram A diagram that shows control, noise, and signal factors along with output response.

percent contribution The pure sum of squares divided by the total sum of squares to express the impact of a factorial effect.

point calibration Calibration of a specific point in measurement.

pooled error variance The error variance calculated by pooling the smaller factorial effects.

preliminary experiment An experiment conducted with only noise factors to determine direction and tendencies of the effect of these noise factors. The results of the preliminary experiment are used to compound noise factors.

pure (net) error sum of squares The sum of squares after adding the error terms originally included in the regular sums of squares of factorial effects.

pure (net) sum of squares The sum of squares of a factorial effect after subtracting the error portion.

quality The loss imparted by a product to society from the time the product is shipped.

quality characteristic A characteristic of a product or process that defines product or process quality. The quality characteristic measures the degree of conformity to some known standard.

quality engineering A series of approaches to predict and prevent the problems that might occur in the marketplace after a product is sold and used by the customer under various environmental and applied conditions for the duration of designed product life.

quality function deployment (QFD) The process by which customer feedback is analyzed and results are incorporated into product design. The QFD process is often referred to as determining the "voice of the customer."

quality loss function (QLF) A parabolic approximation of the quality loss that occurs when a quality characteristic deviates from its best or target value. The QLF is expressed in monetary units: the cost of deviating from the target increases quadratically the farther it moves from the target. The formula used to compute the QLF depends on the type of quality characteristic being used.

reference-point proportional equation The equation showing the case when a signal level is used as a reference input.

repeatability The variation in repeated measurements of a particular object with a particular instrument by a single operator.

reproducibility The state whereby the conclusions drawn from small-scale laboratory experiments will be valid under actual manufacturing and usage conditions (i.e., consistent and desirable).

response factor The output of a system or the result of a performance.

response table A table showing level averages of factors.

robust design A process within quality engineering of making a product or process insensitive to variability without removing the sources.

robust technology development An approach to maximize the functionality of a group of products at the earliest stage, such as at research-and-development stage, and to minimize overall product development cycle time.

robustness The condition used to describe a product or process design that functions with limited variability despite diverse and changing environmental conditions, wear, or, component-to-component variation. A product or process is robust when it has limited or reduced functional variation, even in the presence of noise.

sensitivity The magnitude of the output per input shown by the slope of the input/output relationship.

sensitivity analysis Analysis performed to determine the mean values of experimental runs used when the means are widely dispersed.

sequential approximation A method of providing figures to fill the open spots in an incomplete set of data to make data analysis possible.

signal factor A factor used to adjust the output.

signal-to-noise (SN) ratio Any of a group of special equations that are used in experimental design to find the optimum factor-level settings that will create a

robust product or process. The SN ratio originated in the communications field, in which it represented the power of the signal over the power of the noise. In Taguchi methods usage, it represents the ratio of the mean (signal) to the standard deviation (noise). The formula used to compute the SN ratio depends on the type of quality characteristic being used.

signal-to-noise (SN) ratio analysis Analysis performed to determine the factor levels required to reduce variability and achieve the ideal function of a characteristic.

six sigma A quality program developed by Motorola Corporation with a detailed set of quality processes and tools.

slope calibration Calibration of slope in measurement.

smaller-the-better characteristic The type of performance characteristic parameter that has zero as the best value (e.g., wear, deterioration, etc.). This type of characteristic belongs to the category of quality characteristics that has zero as the best value and has no negative value.

speed difference method The SN ratio of a dynamic operating window calculated from the difference of two quality modes.

speed ratio method The SN ratio of a dynamic operating window calculated from the ratio of two quality modes.

split-type analysis A method to determine SN ratios without noise factors.

standard deviation A measure of the spread of the process output or the spread of a sampling statistic from the process (e.g., of subgroup averages). Standard deviation is denoted by the Greek letter σ (sigma).

standard rate of mistake The rate of mistake when type I and type II mistakes are adjusted to be equal.

standard SN ratio The SN ratio calculated from the standard rate of mistake.

subsystem A system to consist as part of the total system.

system design The first of three design stages. During system design, scientific and engineering knowledge is applied to produce a functional prototype design. This prototype is used to define the initial settings of a product or process design characteristic.

Taguchi methods Methods originated by Genichi Taguchi such as quality engineering, MTS, or experimental regression analysis.

tolerance design The third of three design stages. Tolerance design is applied if the design is not acceptable at its optimum level following parameter design. During tolerance design, more costly materials or processes with tighter tolerances are considered.

transformation The function of transforming the input signal, such as mold dimension or CNC machine input program, into the output, such as product dimension.

tuning factor A signal factor used to adjust the output.

two-step optimization An approach used in parameter design by maximizing robustness (SN ratio), first finding the optimum control factor set points to minimize sensitivity to noise and then adjusting the mean response to target.

upstream quality Also called *robust quality*. This is the type of quality used to improve the robustness of a specific product.

variability The property of exhibiting variation (i.e., changes or differences).

variance The mean-squared deviation (MSD) from the mean. The sum of squares divided by the degrees of freedom.

variation The inevitable differences among individual outputs of a process.

variation of a factor The sum of squares of a factorial effect.

Youden square An incomplete Latin square.

zero-point proportional equation The equation showing the case when the input/output regression line passes through the origin. The equation most frequently used in dynamic characteristics.