

Statistics Training

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Courses:

Design of Experiments (DOE)

Mixture Experiments

Statistical Process Control (SPC)

Short Run SPC and Related Topics

Measurement System Analysis (MSA)

Reliability Estimation (non-repairable systems)

Analyzing Data for Repairable Systems

Statistical Tolerancing

Design of Experiments (DOE)

Design of experiments is a topic for engineering teams faced with understanding the relationship between many factors (“x” variables) and one or more response variable(s), “y”. This can be in the context of optimizing a manufacturing process or designing a new product such that it meets performance goals and/or is robust to manufacturing/end use variation. Design of experiments is a strategy for conducting the most efficient experiments and interpreting the results using statistical methods.

Topical outline

- Experimental strategy
- Experimental error
- Statistics review
- 2^k Factorial design
- Fractional 2^k design
- Response surface designs
- References
- Software

4 hour introduction, in person or via web conference

Application examples:

- Finding the 3-5 variables out of 18 that have the largest effect on a printed circuit board defect called “pink ring”.
- A problem with the solder on the leads of a CPU was solved by running an experiment to determine which of 5 possible causes had the largest effect.
- A response surface model was developed to find the optimal combination of 3 factors known to affect the shear strength in a wire bonding process.
- Design of a market research survey using factorial design strategy for combining product specifications, features and price.
- Solving problems with the creation of “craters” during an epoxy cure process due to out-gasing.

Mixture Experiments

Mixture experiments are special response surface designs (designed experiments) in which factors are components of a mixture and constrained to add up to the whole. These experiments are common in biological and chemical processes. DOE is a prerequisite.

Topical outline

- Review of response surface methods
- Mixture experiment methods
- Mixture Designs
- Example
- References
- Software
- Appendix – Minitab instructions for the example

4 hours either in person or via web conference

Statistical Process Control (SPC)

This is a course in the use of statistical control charts and process capability assessment. The concept of statistical control is introduced and how to address “common causes” versus “special causes” of process variation. The distinction between statistical control limits and process specification limits is highlighted. The process of collecting the data to construct a control chart is reviewed including the concepts of rational subgroups, sample size, independence assumptions and a decision tree for selecting the right control chart algorithms.

Control charts discussed include:

- P-chart
- NP-chart
- C-chart
- U-chart
- Individual Measurements Chart
- Xbar-R
- Xbar-S

In addition, the course covers process capability assessment and the use of indices such as C_p , C_{pk} and C_{pm} .

4 hours either in person or via web conference

Application examples:

- P-chart to monitor the yield of a surface mount process
- U-chart to monitor the rate of “out-of-box” defects experienced by customers
- X-chart to monitor the inventory dollars held in a product line
- Xbar-Sigma chart for service department turn around times

Short Run SPC and Related Topics

This course covers the situation where production may be high mix and/or low volume. In this situation, standard control charting methods can take a long time to get sufficient data to establish the chart. Short run SPC uses data transformation to be able to plot multiple “parts” on the same control chart. The advantage of this is faster establishment of the chart and control of the process. The SPC course is a prerequisite. Additional topics include sampling, distributions commonly used in SPC and additional discussion of rational subgrouping.

2-3 hours depending on topics covered, in person or via web conference

Measurement System Analysis (MSA)

This course introduces the concepts and analytical methods for conducting an analysis of the uncertainty (variation) that is part of a measurement system. Here a measurement system refers to the combination of the measuring device itself, the procedures for taking the measurement, the people taking the measurement and the parts (or devices) being measured. The objective of an MSA is to understand the contribution of each of the components of the measurement system to the total variation in the observed values. MSA studies are often vital before conducting designed experiments or doing control charts to ensure the data taken can be considered reliable enough to accomplish the objective.

Topical Outline

- Partitioning variation
- DOE/ANOVA method
- Quantifying capability of a measurement process
- Estimating test error rates and associated costs
- Setting test limits relative to product specifications
- More than one test instance – the production test situation
- More than one test parameter
- MSA application and references
- Appendix with additional topics
 - Calibration
 - Linearity
 - Stability

4 hrs either in person or via web conference

Application examples:

- Identify the largest sources of variation in a production test process for cellular phones.
- Estimate the misclassification rates – false failures and missed faults – and associated costs in a customer’s production process for PDA’s.
- Quantify the capability of a test solution for the manufacture of power amplifiers used in cellular phone base stations

Reliability Estimation

This course describes how to fit a life distribution to time to failure data. The Weibull distribution is the focus but the exponential and lognormal are also discussed. The manual probability plotting method is presented as well as analysis using two different software packages. In addition to reliability prediction, the class also shows how to estimate when a given percentage of products will fail. This course deals with non-repairable systems where the first failure is terminal.

Topics include:

- Bath tub curve
- Weibull distribution and properties
- Relationship to other common models
- Weibull probability plot and estimation of parameters
- Reliability estimation using the Weibull
- Numerous application examples
- Optional: software tutorial

4 hrs either in person or via web conference

Application examples:

- Analyze time to failure data to determine whether it is better to recall a product in the field known to contain an unreliable component or simply fix the product as they are returned for repair under warranty.
- Estimate the reliability of a product using data in which there have not yet been any observed failures.
- Compare the fitted models from two time-to-failure data sets to determine whether there is a significant difference in the change in failure rates over time.

Analyzing Data for Repairable Systems

Many of the standard reliability methods are intended for non-repairable systems. Here, when the component, subassembly or system fails, it is not returned to service. The Weibull distribution and other well-known distributions which effectively describe the time to failure assume the failures are “terminal”. That is, the whole system is replaced. In contrast, repairable systems may fail multiple times during their lifetimes and this results in “recurrent events” in which system components may be repaired or replaced to bring the system back on line. In this case, a single system actually has multiple ages. That is, components which have been repaired or replaced are “younger” than the rest of the system. Reliability data comprised of recurrent events should be analyzed differently than time to failure data from non-repairable systems. This course presents methods for analyzing recurrent events. An example from a warranty data base is used to motivate the discussion.

Topical outline

- Repairable systems
- Recurrent events
- Recurrent data example
- Homogeneous Poisson process (HPP)
- Non homogeneous Poisson process (NHPP)
- Modeling trend in cumulative failures
- Mean cumulative function (MCF)
- Graphical analysis example
- NHPP warranty analysis example
- Software
- References

4 hrs either in person or via web conference

Statistical Tolerancing

This course describes how to determine limits which bound a desired proportion of the population with high probability. It also covers how to compute tolerances for “systems” comprised of possibly many “components” each with tolerances.

Outline:

- Computing tolerances directly from measurements on a response
 - Normal distribution theory
 - Power transformation for certain non-normal cases
 - Distribution-free tolerance limits

- Inferring system tolerance limits from component tolerances
 - Root sum of squares (RSS) statistical tolerancing defined, assumptions noted with information on what to do about violations

- Optional: setting production test limits relative to product specs

2 hrs either in person or via web conference

Application examples:

- Estimate the tolerances for the break down voltage of a particular electronic component.
- Estimate the tolerances on a complex system comprised of many components each with their own tolerances.