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         3. Control chart for probe precision
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      2. What are PPC Studies Used For?
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4. Process Modeling - Detailed Table of Contents

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- 1. What is process modeling?
- 2. What terminology do statisticians use to describe process models?
- 3. What are process models used for?
  - 1. Estimation
  - 2. Prediction
  - 3. Calibration
  - 4. Optimization
- 4. What are some of the different statistical methods for model building?
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  - 2. Nonlinear Least Squares Regression
  - 3. Weighted Least Squares Regression
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2. Underlying Assumptions for Process Modeling
- 1. What are the typical underlying assumptions in process modeling?
  - 1. The process is a statistical process.
  - 2. The means of the random errors are zero.
  - 3. The random errors have a constant standard deviation.
  - 4. The random errors follow a normal distribution.
  - 5. The data are randomly sampled from the process.
  - 6. The explanatory variables are observed without error.

3. Data Collection for Process Modeling
- 1. What is design of experiments (DOE)?
- 2. Why is experimental design important for process modeling?
- 3. What are some general design principles for process modeling?
- 4. I've heard some people refer to "optimal" designs, shouldn't I use those?
- 5. How can I tell if a particular experimental design is good for my application?

4. Data Analysis for Process Modeling
- 1. What are the basic steps for developing an effective process model?

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    2. What are Process Control Techniques?
    3. What is Process Control?
    4. What to do if the process is "Out of Control"?
    5. What to do if "In Control" but Unacceptable?
    6. What is Process Capability?

2. Test Product for Acceptability: Lot Acceptance Sampling
    1. What is Acceptance Sampling?
    2. What kinds of Lot Acceptance Sampling Plans (LASPs) are there?
    3. How do you Choose a Single Sampling Plan?
        1. Choosing a Sampling Plan: MIL Standard 105D
        2. Choosing a Sampling Plan with a given OC Curve
    4. What is Double Sampling?
    5. What is Multiple Sampling?
    6. What is a Sequential Sampling Plan?
    7. What is Skip Lot Sampling?

3. Univariate and Multivariate Control Charts
    1. What are Control Charts?

- 2. What are Variables Control Charts?
  - 1. Shewhart X-bar and R and S Control Charts
  - 2. Individuals Control Charts
  - 3. Cusum Control Charts
    - 1. Cusum Average Run Length
  - 4. EWMA Control Charts
- 3. What are Attributes Control Charts?
  - 1. Counts Control Charts
  - 2. Proportions Control Charts
- 4. What are Multivariate Control Charts?
  - 1. Hotelling Control Charts
  - 2. Principal Components Control Charts
  - 3. Multivariate EWMA Charts

4. Introduction to Time Series Analysis
- 1. Definitions, Applications and Techniques
- 2. What are Moving Average or Smoothing Techniques?
  - 1. Single Moving Average
  - 2. Centered Moving Average
- 3. What is Exponential Smoothing?
  - 1. Single Exponential Smoothing
  - 2. Forecasting with Single Exponential Smoothing
  - 3. Double Exponential Smoothing
  - 4. Forecasting with Double Exponential Smoothing(LASP)
  - 5. Triple Exponential Smoothing
  - 6. Example of Triple Exponential Smoothing
  - 7. Exponential Smoothing Summary
- 4. Univariate Time Series Models
  - 1. Sample Data Sets
    - 1. Data Set of Monthly CO2 Concentrations
    - 2. Data Set of Southern Oscillations
  - 2. Stationarity
  - 3. Seasonality
    - 1. Seasonal Subseries Plot
  - 4. Common Approaches to Univariate Time Series
  - 5. Box-Jenkins Models
  - 6. Box-Jenkins Model Identification
    - 1. Model Identification for Southern Oscillations Data
    - 2. Model Identification for the CO2 Concentrations Data
    - 3. Partial Autocorrelation Plot
  - 7. Box-Jenkins Model Estimation
  - 8. Box-Jenkins Model Diagnostics
    - 1. Box-Ljung Test
  - 9. Example of Univariate Box-Jenkins Analysis
  - 10. Box-Jenkins Analysis on Seasonal Data
- 5. Multivariate Time Series Models
  - 1. Example of Multivariate Time Series Analysis

5. Tutorials
- 1. What do we mean by "Normal" data?
- 2. What do we do when data are "Non-normal"?
- 3. Elements of Matrix Algebra
  - 1. Numerical Examples
  - 2. Determinant and Eigenstructure
- 4. Elements of Multivariate Analysis
  - 1. Mean Vector and Covariance Matrix
  - 2. The Multivariate Normal Distribution
  - 3. Hotelling's T squared
    - 1. T2 Chart for Subgroup Averages -- Phase I
    - 2. T2 Chart for Subgroup Averages -- Phase II
    - 3. Chart for Individual Observations -- Phase I
    - 4. Chart for Individual Observations -- Phase II
    - 5. Charts for Controlling Multivariate Variability
    - 6. Constructing Multivariate Charts
- 5. Principal Components
  - 1. Properties of Principal Components

      2. Numerical Example

  6. Case Studies in Process Monitoring
    1. Lithography Process
      1. Background and Data
      2. Graphical Representation of the Data
      3. Subgroup Analysis
      4. Shewhart Control Chart
      5. Work This Example Yourself
    2. Aerosol Particle Size
      1. Background and Data
      2. Model Identification
      3. Model Estimation
      4. Model Validation
      5. Work This Example Yourself

  7. References

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 7. Product and Process Comparisons
  1. Introduction
    1. What is the scope?
    2. What assumptions are typically made?
    3. What are statistical tests?
      1. Critical values and p values
    4. What are confidence intervals?
    5. What is the relationship between a test and a confidence interval?
    6. What are outliers in the data?
    7. What are trends in sequential process or product data?

  2. Comparisons based on data from one process
    1. Do the observations come from a particular distribution?
      1. Chi-square goodness-of-fit test
      2. Kolmogorov- Smirnov test
      3. Anderson-Darling and Shapiro-Wilk tests
    2. Are the data consistent with the assumed process mean?
      1. Confidence interval approach
      2. Sample sizes required
    3. Are the data consistent with a nominal standard deviation?
      1. Confidence interval approach
      2. Sample sizes required
    4. Does the proportion of defectives meet requirements?
      1. Confidence intervals
      2. Sample sizes required
    5. Does the defect density meet requirements?
    6. What intervals contain a fixed percentage of the population values?
      1. Approximate intervals that contain most of the population values
      2. Percentiles
      3. Tolerance intervals for a normal distribution
      4. Tolerance intervals based on the largest and smallest observations

  3. Comparisons based on data from two processes
    1. Do two processes have the same mean?
      1. Analysis of paired observations
      2. Confidence intervals for differences between means
    2. Do two processes have the same standard deviation?
    3. How can we determine whether two processes produce the same proportion of
defectives?
    4. Assuming the observations are failure times, are the failure rates
    (or Mean Times To Failure) for two distributions the same?
    5. Do two arbitrary processes have the same central tendency?

  4. Comparisons based on data from more than two processes
    1. How can we compare several populations with unknown distributions
    (the Kruskal-Wallis test)?
    2. Assuming the observations are normal, do the processes have the same

variance?
3. Are the means equal?
1. 1-Way ANOVA overview
2. The 1-way ANOVA model and assumptions
3. The ANOVA table and tests of hypotheses about means
4. 1-Way ANOVA calculations
5. Confidence intervals for the difference of treatment means
6. Assessing the response from any factor combination
7. The two-way ANOVA
8. Models and calculations for the two-way ANOVA
4. What are variance components?
5. How can we compare the results of classifying according to several categories?
6. Do all the processes have the same proportion of defects?
7. How can we make multiple comparisons?
1. Tukey's method
2. Scheffe's method
3. Bonferroni's method
4. Comparing multiple proportions: The Marascuillo procedure

5. References
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8. Assessing Product Reliability
1. Introduction
1. Why is the assessment and control of product reliability important?
1. Quality versus reliability
2. Competitive driving factors
3. Safety and health considerations
2. What are the basic terms and models used for reliability evaluation?
1. Repairable systems, non-repairable populations and lifetime distribution models
2. Reliability or survival function
3. Failure (or hazard) rate
4. "Bathtub" curve
5. Repair rate or ROCOF
3. What are some common difficulties with reliability data and how are they overcome?
1. Censoring
2. Lack of failures
4. What is "physical acceleration" and how do we model it?
5. What are some common acceleration models?
1. Arrhenius
2. Eyring
3. Other models
6. What are the basic lifetime distribution models used for non- repairable populations?
1. Exponential
2. Weibull
3. Extreme value distributions
4. Lognormal
5. Gamma
6. Fatigue life (Birnbaum-Saunders)
7. Proportional hazards model
7. What are some basic repair rate models used for repairable systems?
1. Homogeneous Poisson Process (HPP)
2. Non-Homogeneous Poisson Process (NHPP) - power law
3. Exponential law
8. How can you evaluate reliability from the "bottom-up" (component failure mode to system failure rate)?
1. Competing risk model
2. Series model
3. Parallel or redundant model
4. R out of N model
5. Standby model
6. Complex systems

    9. How can you model reliability growth?
        1. NHPP power law
        2. Duane plots
        3. NHPP exponential law
    10. How can Bayesian methodology be used for reliability evaluation?

2. Assumptions/Prerequisites
    1. How do you choose an appropriate life distribution model?
        1. Based on failure mode
        2. Extreme value argument
        3. Multiplicative degradation argument
        4. Fatigue life (Birnbaum-Saunders) model
        5. Empirical model fitting - distribution free (Kaplan-Meier) approach
    2. How do you plot reliability data?
        1. Probability plotting
        2. Hazard and cum hazard plotting
        3. Trend and growth plotting (Duane plots)
    3. How can you test reliability model assumptions?
        1. Visual tests
        2. Goodness of fit tests
        3. Likelihood ratio tests
        4. Trend tests
    4. How do you choose an appropriate physical acceleration model?
    5. What models and assumptions are typically made when Bayesian methods are used for reliability evaluation?

3. Reliability Data Collection
    1. How do you plan a reliability assessment test?
        1. Exponential life distribution (or HPP model) tests
        2. Lognormal or Weibull tests
        3. Reliability growth (Duane model)
        4. Accelerated life tests
        5. Bayesian gamma prior model

4. Reliability Data Analysis
    1. How do you estimate life distribution parameters from censored data?
        1. Graphical estimation
        2. Maximum likelihood estimation
        3. A Weibull maximum likelihood estimation example
    2. How do you fit an acceleration model?
        1. Graphical estimation
        2. Maximum likelihood
        3. Fitting models using degradation data instead of failures
    3. How do you project reliability at use conditions?
    4. How do you compare reliability between two or more populations?
    5. How do you fit system repair rate models?
        1. Constant repair rate (HPP/exponential) model
        2. Power law (Duane) model
        3. Exponential law model
    6. How do you estimate reliability using the Bayesian gamma prior model?
    7. References For Chapter 8: Assessing Product Reliability