

Course ID

**S-TOL-ANAL**

Course Duration

**2 days**

Course Title

**Statistical Tolerance Analysis: A Comprehensive Workshop**

**Related Courses**

- Geometric Dimensioning and Tolerancing (GDT&T, 2 days)
- Statistical Process Control (SPCON, 3 days)
- Cost Reduction: Opportunities and Strategies (COSTRED, 2 days)
- Quality Management (QUALMGT, 3 days)

**Aimed At**

This course is aimed at engineers, design engineers, and engineering managers.

**Group Size**

5-25

**Prerequisites**

While there are no formal prerequisites, the course assumes an engineering background.

**Course in a Nutshell**

Statistical tolerance analysis identifies likely dimensional variation in mechanical designs. Similar to the more conventional worst case tolerance analysis approach, statistical tolerance analysis more realistically assesses the effects of tolerance stackups to identify likely tolerance variations. Statistical tolerance analysis is a tool for intelligently allocating less-stringent tolerances and for assessing the likelihood of unacceptable tolerance combinations. Using this approach allows engineering organizations to create more producible and less expensive products.

The *Statistical Tolerance Analysis* course is an intense training program focused on both root sum square and Monte Carlo tolerance analysis approaches. The course includes important tolerance allocation approaches that will allow your organization to assign less stringent, higher quality, and more sensible tolerances to your designs. The course thoroughly covers the theoretical aspects of these advanced tolerance analysis and allocation approaches. The course includes numerous practical examples, exercises, and approaches for using Excel and Visual Basic for Applications (included in Excel) for making these determinations.

**Customize It!**

Whatever the nature of your systems, products, and objectives, we will customize the course to meet your specific needs and concerns. Here are some of the ways in which we can tailor the course to help you get more out of it:

- Additional “workshop days” to allow the participants to work together to address statistical tolerance analysis topics specific to your organization. The workshop day can be scheduled a few weeks after the course to allow time for applying the technologies presented in class under an experienced engineer.
- Schedule post-class follow-up consultation for continuing in-house statistical tolerance analysis implementation.

**Learn How To** • Work together to implement statistical tolerance analysis concepts.

## **Course Outline**

### **Day 1: Fundamentals, Worst Cost, and Root Sum Square Approaches**

- **Tolerance Analysis Fundamentals.** The nature of dimensioning and tolerancing. Tolerance analysis purposes. Tolerance analysis history. How tolerances are typically assigned. Tolerance analysis concepts. Worst case tolerance analysis and worst case tolerance analysis shortfalls. Statistical tolerance analysis and statistical tolerance analysis shortfalls. Differences between worst case tolerance analysis and statistical tolerance analysis. Suggested tolerance analysis approach selection criteria.
- **Basic Statistical Considerations.** The nature of variability. The normal distribution. Means and standard deviations. Manufacturing process variability. Process capability,  $C_p$ , and  $C_{pk}$ . Tolerances and nominal dimensions versus process capability. Coefficient incorporation to address differences in design nominal and process nominal dimensions.

#### *Exercises.*

- **Statistical Tolerance Analysis Concepts.** Statistical tolerance analysis purposes. Statistical tolerance analysis assumptions. The realism of statistical tolerance analysis. Maximum possible versus maximum probable dimensional variation. Why statistical tolerance analyses predict less variation. The economics of worst case tolerance analysis versus statistical tolerance analysis.
- **Root Sum Square Statistical Tolerance Analysis.** Dimension chains, positive versus negative directions, and converting to equal-bilateral format. Finding the root sum square of all tolerances. Knowing the manufacturing process and assembly shift, and incorporating adjustment coefficients. Applying statistical tolerance analysis findings for dimensional predictions. Using statistical tolerance analysis for relaxing component tolerances. Using Excel.

#### *Exercises.*

### **Day 2: Monte Carlo and Advanced Concepts**

- **Monte Carlo Tolerance Analysis.** The Monte Carlo approach. Differences in Monte Carlo simulation approaches. Applying uniform versus normal distributions in the simulation. Randomness and normal statistical variation. Monte Carlo simulations with Excel and VBA for Excel. Statistical tolerance analysis versus Monte Carlo tolerance analysis considerations.

#### *Exercises.*

- **Tolerance Allocation Approaches.** Typical tolerance assignment approaches. Tolerance allocation based on worst case, root sum square, and Monte Carlo tolerance analysis. Tolerance allocation incorporating the tolerance analysis approach and component size, process capability, cost, and mean shift. Using Excel for tolerance allocation.

*Exercises.*

- **Assessing Statistical Tolerance Analysis Applicability.** Number of tolerances. Production quantities. Process controls and process capability. Centered processes versus nominal dimensions. Design sensitivity. Interchangeability. Independent variables. Suggested guidelines.
- **Quality and Economics Considerations.** Costs and benefits associated with statistical tolerance analysis. Costs associated with tighter versus looser tolerances. Rejections as a result of statistical tolerance analysis approaches. Using statistical tolerance analysis to predict assembly rejection rates. Targeting tolerance relaxation candidates.
- **Other Considerations.** Non-normal distributions. Factor weighting by individual tolerance. Risks and risk management.
- **Course Wrap-Up.** Course review. Questions and answers. Plans for future actions. Course critique.

**How You Will Learn**

- A seasoned consulting engineer-instructor will present this course in interactive lecture/workshop format.
- Along with the lectures, we use exercises, puzzles, case studies, and interesting group activities to enrich the instruction and drive home the essential points.
- You will receive a printed Participant Handbook that includes all materials presented in class, which will help you remember and retain what you learned and apply it on your job.
- You will learn statistical tolerance analysis concepts from theoretical and practical perspectives.

Revision 2Jm-f