Tolerance Stack Analysis (TSA) including GD&T and Statistical Tolerancing Course Outline

Overview and Purpose
This customized three-day course will provide you with step-by-step methods for determining the clearance/interference relationships on components and assemblies that have been toleranced using coordinate dimensioning and Geometric Dimensioning and Tolerancing (GD&T). After understanding the interpretation of related GD&T applications, participants will perform multiple component and assembly tolerance studies to determine a variety of worst mating conditions involving size, form, orientation, and location. You will also be introduced to basic statistical methods and capability analysis as related to GD&T, Tolerance Analysis, Statistical Tolerancing, and Design for Six Sigma using Microsoft Excel.

Who Should Attend
This advanced course is intended for personnel who are already familiar with the GD&T principles and practices as related in ASME Y14.5M-1994 and ISO 1101 and related standards. The course is designed for engineering, design, manufacturing, quality, or other related personnel who need to better understand the interpretation and application of GD&T, as well as conventional tolerancing methods, to perform tolerance analysis on new and existing designs.

Prerequisite
GD&T Fundamentals within the previous 5 years.

Here's What You'll Learn
- How to reduce tolerance accumulation and variation in your products.
- How to perform and develop tolerance stacks using various methods including Microsoft Excel templates and software-based techniques.
- How to interpret and apply GD&T during tolerance analysis.
- How to use tolerance stacks to logically select and apply datums, dimensions, and tolerances.
- How to calculate tolerances by properly selecting and using tolerance stack methods and formulas.
- How to optimize dimensions and tolerances to improve design fit and function.
- How to increase part tolerance without compromising quality.
- How to determine appropriate tolerances based on product and process variation and capability.
- How to forecast component and assembly variation using statistical methods and Microsoft Excel.
- How to use GD&T and tolerance analysis as a tool to achieve Design for Six Sigma.
- How to use stacks to determine whether to apply position, concentricity, circular runout, or total runout.
- How to use tolerance stacks to address non-conformances; facilitate design changes; more quickly and safely "buy off" out-of-spec parts; and reduce scrap, rework, and time-to-market.

About Your Instructor
Dan Bauer, Integrated Training Resources, Inc. Mr. Bauer, an ASME Certified Senior GD&T Professional who holds a Master of Science in Industrial Operations and is fluent in Spanish, serves as president and principal consultant with ITR. With experience supporting over 120 automotive component and vehicle programs over the past 20 years in the U.S., Canada, Mexico, Europe, Japan, and China, Mr. Bauer specializes in providing training and engineering services in the areas of design, quality, performance improvement, and productivity. He has additionally delivered courses in GD&T, SPC and Capability Analysis, and Statistical Process Control for the DaimlerChrysler Quality Institute and General Motors University. Since 1998 he has served a GD&T and quality consultant for the Delphi Mexico Technical Center in Juarez, Mexico. He provides GD&T, engineering, and quality-related training and consulting to various clients in the automotive, telecommunications, aerospace, medical devices, consumer products, and gas and oil industries.

Since 2007 Mr. Bauer has provided training, coaching, and consulting to Schlumberger engineering, design, manufacturing, quality, and supply chain personnel in various areas including Geometric Dimensioning and Tolerancing (GD&T), Tolerance Stack Analysis (TSA), and Design for Manufacturing and Design for Assembly (DFM/DFA).

Key Course Objectives

- Setup and conduct appropriate tolerance analysis on:
  - Components
  - Assemblies
- Perform 10 major types of tolerance stacks:
  - Calculate Worst-Case Mating Boundaries
  - Calculate Virtual Condition
  - Calculate Resultant Condition
  - Calculate Tolerances for Fixed Fastener Applications
  - Calculate Tolerances for Floating Fastener Applications
  - Calculate Tolerances for Mating Multiple Coaxial Diameter Applications
  - Worst-Case Linear Stack
  - Worst-Case Non-Linear (Radial) Stack
  - Statistical Linear Stack
  - Statistical Non-Linear (Radial) Stack
- Demonstrate the effect of material condition modifiers on tolerances
- Introduce statistical tolerancing strategies for tolerance allocation and optimization

Day 1 – GD&T Review and Intro to Tolerance Stacks

- Pre-Assessment and Introductions
- The need for tolerance analysis during product design and production
- Review of most common geometric tolerances, their interpretations and applications
- Review of concepts and applications of ASME Y14.5M-1994 and ISO 1101 and related standards with respect to assigning and interpreting coordinate and geometric tolerances on mating components.
  - Review of Worst Case Boundary calculations for MMC, LMC, and RFS.
  - Review Virtual Condition and Resultant Condition Calculations
  - Review Fixed and Floating Fastener Calculations
- Introduction to Component Stacks
  - Stack methods and conventions
  - Step-by-step method for calculating stacks
  - Calculation of Worst-Case Boundaries
  - Calculation of Minimum Material Thickness
  - Calculation of Minimum Clearance
- Size Stacks for Internal and External Features
- Stacks with coordinate dimensioning and tolerancing
  - Linear component stacks using coordinate tolerancing
  - Linear assembly stacks using coordinate tolerancing
  - Radial component stacks using coordinate tolerancing
  - Radial assembly stacks using coordinate tolerancing
- Application exercise using Microsoft Excel

Day 2 –Stacks with Position, Modifiers, and Datum Shift

- Stacks with position RFS, runout, concentricity, and symmetry
  - Radial component stacks using coordinate tolerancing, position RFS, runout, concentricity, and symmetry
  - Radial assembly stacks using coordinate tolerancing, position RFS, runout, concentricity, and symmetry
- Stacks with position modified MMC or LMC
  - Component stacks with position MMC
  - Assembly stacks with position MMC
  - Component stacks with position LMC
  - Assembly stacks with position LMC
  - Stacks include the effects of Datum Shift or Datum Variation

- Stacks with profile of a surface
  - Component and assembly stacks with profile tolerances
  - Equal bilateral
  - Unequal bilateral
  - Unilateral
  - Profile stacks including the effects of Datum Shift
- Stacks with form tolerances
  - Flatness, Circularity, and Cylindricity
  - Straightness applied to a Surface
  - Straightness applied to a Feature of Size
- Stacks with orientation tolerances
  - Applied to surfaces
  - Applied to Features of Size
  - Resultant linear and angular orientation error on components
  - Resultant linear and angular orientation error on assemblies
  - Basic conversion factors, ratios, and trigonometric relationships
- Component stacks with multiple geometric tolerances
- Assembly stacks with multiple geometric tolerances
- Application exercises using Microsoft Excel

Day 3 – Intro to Statistical Tolerancing

- Review of Day 1-2 Concepts and Applications
- Statistical Probability Theory
- Measures of Central Tendency and Dispersion
  - Mean, Median, Mode
  - Range, Standard Deviation
- The Normal Distribution and Standard Deviation
- Probability and Statistics applied to Tolerance Analysis: Cpk vs. Sigma vs. Tolerance Allocation
- Process Capability (Cpk) Applied to Tolerancing
  - Sigma, Cp, Cpk, Ppk, and Appropriate Tolerances
- Popular Statistical Tolerancing Approaches and Formulas
  - RSS, MRSS, DRSS, and Monte Carlo Analysis
  - Statistical Tolerancing Formulas for Components
  - Statistical Tolerancing Formulas for Assemblies
- From Straight Math Stacks to Statistical Tolerancing
  - Component stacks with multiple geometric tolerances
  - Assembly stacks with multiple geometric tolerances
- Intro to Monte Carlo Analysis
- Application exercise using Microsoft Excel
- Summary of Key Concepts and Applications
- Post-Assessment and Course Evaluation