Design for Reliability Tailored Training Modules

($875 Two Days, $985 Three Days)

Tailor Your Company's Training

Pick & Choose Topics in Reliability, Shock & Vibration, Physics of Failure (Mechanical & Electronic) & ESD Training

(Select Any Modules & Sub Topics, We Will Quote Cost)

This course uses DfRSoftware (www.dfrsoft.com) which is optional.

PART 1: BASIC METHODS IN RELIABILITY & QUALITY

1. Reliability & Quality in Today's Marketplace

- A Practical Approach to Reliability Implementation
- Reliability Growth and ROI
- Reliability as a Differentiator
- The Main Components of a DfRQ Company Program

2. The Stage Gate (Phase) Approach

- Idea, Evaluate, Development, Transition, Production
- Understanding Each Gate - The Tools for your Program
- Piecing it Together - A Value Added Reliability Program

3.Basic Reliability Mathematics

- MTBF/Failure Rate Basics
- Failure Rate Conversion (FITs, FMH, MTBF, PPM, AFR, %Failure)
- System Reliability Analysis & Block Diagrams (Series, Parallel, Redundancy for K of N, Active/Standbys)
- Allocation (equal apportionment and by complexity)
- Reliability Predictions (Parts Count, Detailed Stress, Telcordia, Mil Std 217…)

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4. Advanced Reliability Mathematics

- Time Dependent Failure Rate
- Main Distribution of the Bathtub Curve, Weibull, Exponential, and Lognormal
- Key Reliability Functions (CDF, PDF, Hazard Rate)
- Introduction to Reliability Life Data Plotting Using Software
- Wei-Bayes Analysis
- *Mixed Modes Analysis (see Module 11)*
- How Weibull & Lognormal Distributions Relates to Physics of Failure Aging Laws (Beta significance)

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PART 2: DEMONSTRATING & ANALYZING RELIABILITY

CONCEPT IDEA PHASE

5. How to Develop a Reliability Program Plan Using Top Down FMEA

- Method of Top Down FMEA (Top Down Failure Modes for analysis and test design)
- Top Down FMEA for Program Planning
- Team Approach (Everyone Commits to Program)
- Design Controls & Recommended Actions aid in planning
- How to Make a Program Plan with Top Down Example

5a Bottoms Up Design FMEA

- Key to a Good DFMEA
- Most Efficient DFMEA
- DFMEA Environmental Approach (Component sensitivity)
- Examples

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DESIGN EVALUATION PHASE

6 .Reliability Testing & Reliability Growth (DART - HALT)

- Finding Failure Modes – Test to Fail Not to Pass
- Accelerated Reliability Growth
- Duanne & Crowe AMSAA Models
- Chi-Squared Accelerated Reliability Growth
- Test Design by Failure Modes
- HALT Introduction & Concept, Detailed Test Procedure, Max limits, Failure Judgment
- HALT Helpful Information: Table Assessment, Meetings, Check list, Guidelines,
- HALT Table Vibration Assessment,
- *ED vs. HALT (See Shock & Vibration Module 14)*
- *HASS (see Screening Module 10)*

6A. Introduction to Software Reliability

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7. Design for Reliability Methods

- Reliability Design Safety Margin – Load-Stress Reliability Interference Assessment
- Design Mechanical Safety Factors
- Electrical Derating
- *Assessing Potential Thermal Issues (See Module 19)*
- *Engelmaier IPC Solder Joint Life Model, BGAs* (See Module 19)

DEVELOPMENT PHASE

8. Accelerated Life Models & Environmental Profiling

- Acceleration Factors & Models (Temperature-Arrhenius, Peck Temperature-Humidity, Coffin-Manson Temperature Cycle, Modified Frequency Temperature Cycle, Vibration Accelerated Models, General Power Law Model)
- Acceleration Factors for Creep, Wear develop your own method, See Module 16)
- Chi-squared confidence method for accelerated testing
- Environmental Profiling (model for environments with varying stress profiles)

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9. Reliability Demonstration Testing Using Chi-Squared Method

- Will Your Product Meet its Reliability Objective?
- Design Maturity Test Plans and Flow
- Types of Confidence (Chi-Squared - single and two sided, Excel formulas)
- Testing for a Reliability Failure Rate Objective
- Statistically Significant Confidence Accelerated Test Plans
- Importance of Device Hours
- Pros and Cons of Device Hours
- Device Hours – Multiple Test Uses

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RELIABILITY MANUFACTURING & SUPPORT PHASE

10. Reliability Monitoring and Screening

- Screening vs. Monitoring
- Common Screens and Monitoring Tests
- HASS Screening

11. Field Returns and Device Hours

- AFR – Most common company metric
- Field Return – Data Analysis
- Device Hours – Multiple Test Uses and Field Returns
- Field Return– Weibull Analysis, Mixed FM, (two populations)
- Mixed Modes Analysis (field returns, two or more populations)

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12.Availability & Sparing

- Exponential Distribution with Binomial Confidence (other methods - Weibull)
- Why availability can be a better number for customers than MTBF

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13a.Basic Quality Test Engineering

- Cpk, Yield, Normal/Lognormal, & Six Sigma Analysis
- SPC Charts
- Visual Inspection/Design Release

13b. Lot Sampling detail in lot sampling (single and double sampling)

13c. Design of Experiment with Multiple Regression

13d. Stack Up & Monte Carlo Analysis Methods

- Stack up
- Worst case stack up analysis
- Stack up Example
- Monte Carlo Methods for stack up

PART 3 SPECIAL TOPICS TAILORED TO THE CLASS' NEEDS

14. Understanding Shock & Vibration and Related Tests

14a. Shock

- Overview of Shock & Vibration
- What is a G, g, Grms, G-force

- Shock testing; electrodynamic (ED), drop shock
- Shock Equipment; ED, Air Shock, Incline, Drop Shock, Tower Test
- Common types of shock pulses
- How does 1G free fall create large G shocks?
- Physics of drop shock; different pulse shapes, rebound effect
- Drop height for different masses; PE method
- Calculating drop height for different pulse shapes
- Shock Fatigue Testing
- Shock Response Spectrum (SRS); pyroshock, earthquake, seismic shock
- Shock & package test references; Mil-STD, ASTM, ISTA

14b. Sine Vibration

- Basics of sine testing using the ED shaker, test fixtures
- ED Vibration Lab Set-up - Similar to Car Stereo
- Fixtures & ED Shaker Test Limits
- Sine wave basics; phase effect, track & dwell, resonance & Q
- Sine wave math – amplitude, velocity, acceleration
- Transmissibility, Q, two graphical methods for Q
- Harmonic oscillator physics; natural & forcing frequency, academic & real world Q
- Details of damping, transmissibility Q, resonance
- Sine amplitude equations with Q factor
- Sweep Rate – Octaves, consequences of too fast a sweep rate
- Dwell sine testing
- Sine Fatigue Life S-N Curves, how the b factor effects the acceleration model
- Accelerated testing using S-N curve information or historic information
- High G level testing, G, RPM

14c. Random vibration testing

- Why random
- Understanding random frequency & time domain
- Fourier Transform – White Noise
- Why sine & random are hard to compare
- ED vs. repetitive shock
- Some PSD Specs.
- Calculating Grms from PSD spectrum; hand and complex calculation using DfRSsoft tool,
- PSD slope (dB/Octave)
- Transportation vibration exposure
- Random vibration accelerated cyclic testing fatigue life estimation
- Estimating Q from random vibration data
- Tri-axial fixturing, X, Y, Z data, tri-axial testing
- Accelerometers
- Sine-on-random, Random-on-random

14d. HALT Repetitive Shock Vibration

- ED vs. HALT
- HALT Table PSD-frequency Profile

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15. Design Considerations in Shock & Vibration

Isolation & Damping - Designing for Vibration & Shock Suppression

- Vibration Isolation

- Shock Isolation/Absorption
- Packaging guidelines - foam thickness
- Vibration Absorption/Damping

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16. Mechanical Physics of Failure & Material Selection Stress Considerations

- Elastic deformation, yielding (with vibration) and ductile rupture (with shock) material considerations
- Creep & cumulative creep fatigue material considerations, viscoelastic creep, creep acceleration factor
- Excessive wear; friction & lubrication – types of wear, vibration wear, material selection & hardness, wear acceleration factor
- Cyclic Fatigue: Exact method for damage estimation (derivation using thermodynamic work)
- Miner's approximation – derivation, why it is an approx., stress concentration
- SN curves – material selection
- Fatigue (SN curves, Basquin's and Coffin-Manson -high and low cyclic fatigue, Loading Types - stress corrections, Facture Mech. Vibration fatigue, when SN Curves not available)
- PCB fatigue life - Circuit board component fatigue life model analysis –Steinberg Method (sine and random)
- Thermal cycle (strain, fatigue, acceleration factors derivations for Coffin-Manson & Modified, Norris-Landzberg
- Method of Combing Thermal & Vibration fatigue

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17. Physics of Failure 7 Step Problem Solving

- Being a detective
- Friendly Databases

18. Physics of Failure Analysis Tools

- Digital Microscopy
- SEM (FE-SEM, EDS)
- Focused Ion Beam
- Scanning Auger
- C-SAM
- Real Time Radiology, X-Ray Maps, ○ X-Ray Fluorescence XRF
- FTIR, Thermal Imaging
- Functional Electrical Test (Curve Trace)
- EMI, EMC Testing

19. Electronic & IC Physics of Failure Considerations

- Thermal Cycle CTE Stress Issues
    - CTE's Mismatch, Thermal Fatigue
    - Engelmaier IPC Solder Joint Life Model, BGAs
    - Underfill & Modification to Englemaier model
- Drop shock & vibration Electronic Failure modes
- Temperature: Thermally Activated Failure Modes
    - Top IC Failure Modes due to Heat, Popcorn Cracking, Voiding Delamination
    - Junction Temperature Issues & Modeling
- Voltage Issues

- ESD and EOS – Dielectric Breakdown
- Current Density & Fusing of Bond wires and wires
- Misc PoF Failure Modes
  - Design Warnings
  - Electrolytic Caps
  - Assembly Errors
  - IC Failure Modes (Latch up, Gate Sinking, Hot Carrier,…)
  - Solder Failures (non wetting, grain size, leaching, coverage)
  - Intermetallics - Au Embrittlement, Purple Plague
- Corrosion
  - Corrosion Requirements
  - Key Forms of Corrosion (General, Galvanic, stress corroiosn,Cl,)
  - Moisture & Waterproofing (Conformal Coating, Encapsulation, Super Hydrophobic)
  - Dendritic Growth, Ag Migration & Electromigration
- RoHS Lead Free Solder Issues
  - Lead Free Issues: European directive, Pb-Free Failure Modes, SAC Solders
  - PCB Copper Dissolution from reflow - Via issues, PCB CTE Z-direction issues
  - Surface finishes (ENIG,Immersion Silver, Immersion Tin, OSP, Benefits, Issues)
  - Tin Whisker

20. Cutting Edge Physics of Failure Methods and Models

- Work Approach to Obtaining a Physics of Failure Aging Law (Example: Creep, Wear)
- Using Free Energy Method to Assessing Life (Experimentally and Modeling)
- Generate an SN Curve using established rules (including notches, grain size, etc.)
- Weibull Beta to obtain physics of failure power aging laws
- Subtle Prognostics Using Noise (a subtle way to measure impending failure when obvious signs are not producing results)
- 1/f Noise in Oscillators and Other Devices - Reliability Considerations

21. Parametric Reliability

- Component Drift Analysis Methods & Sample Size Advantages

22. ESD Concepts

Advanced CDM

- Introduction CDM compared to HBM
- Why Ionizers can be important
- CDM Case Studies on Test Fixtures and Common ESD Problem
- Advanced Audits/Investigation, Test Fixtures
- Assessing ESD: Difficulty in Failure Analysis

ESD Protection Devices & Circuits

- ESD Test Circuits: Component vs. System Testing
- Protection Devices & Protection Circuits: Diodes, Varistors, Transistor Circuits, Discretes, Spark Gaps, PESD, L-R-C Passive Devices, and Mechanical Protection

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23. Putting it all Together