Tailor Your Company's Training – Pick & Choose Topics
Reliability, Shock & Vibration, Physics of Failure (Mechanical & Electronic) & ESD Training

Courses use DfRSoftware which is optional but helpful.

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 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 (Using DfRSoft Tools)

- 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…)
- Advanced Reliability Mathematics (See Module 8)

Homework with Solutions

4a.Basic Quality Test Engineering
(Using DfRSoft Tools)

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

4b. Lot Sampling detail in lot sampling
4c. Design of Experiment with Multiple Regression
4d. Stack Up & Monte Carlo Analysis Methods

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

PART 2: DEMONSTRATING & ANALYZING RELIABILITY
CONCEPT PHASE – (IDEA) PHASE

5. How to Develop a Reliability Program Planning

- Method of Top Down FMEA
- Top Down FMEA for Program Planning

- Team Approach
- Design Controls & Recommended Actions
- 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

DESIGN PHASE – (EVALUATION) – PHASE

6 .Design Assessment Reliability Testing & Reliability Growth (DART - HALT)
(DfRSoft Tools)

- Finding Failure Modes – Test to Fail Not to Pass
- Accelerated Reliability Growth
- 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 11)*

Homework with Solutions

7. Design for Reliability Methods

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

DEVELOP - PHASE

8. Advanced Reliability Mathematics
(Using DfRSoft Tools)

- 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
- *Mixed Modes Analysis (see Module 12)*
- How the Weibull & Lognormal Distributions Relates to Physics of Failure Aging Laws (Beta significance)

Homework with Solutions

9. 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)
- Chi-squared confidence method for accelerated testing

- Environmental Profiling (model for environments with varying stress profiles)

Homework with Solutions

10. Design Maturity Chi-Squared Demonstration Testing (Using DfRSoft Tools)

- Will Your Product Meet its Reliability Objective?
- Design Maturity Test Plans and Flow
- Types of Confidence
- 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

Homework with Solutions

RELIABILITY MANUFACTURING & SUPPORT PHASE

11. Reliability Monitoring and Screening

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

12.Field Returns and Device Hours (DfRSoft Tools)

- AFR – Most common company metric
- Field Return– Raw 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)

Homework with Solutions

13.Availability & Sparing (DfRSoft Tools) (Less time)

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

Homework with Solutions

PART 3 SPECIAL TOPICS TAYLORED TO THE CLASS' NEEDS

14. Understanding Shock & Vibration and Related Tests

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

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

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

HALT Repetitive Shock Vibration

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

Homework with Solutions

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

Homework with Solutions

16. Mechanical Physics of Failure & Material Selection Stress Considerations

- ***Elastic deformation, yielding (with vibration) and ductile rupture*** (with shock) material considerations

o ***Creep*** & cumulative creep fatigue material considerations, viscoelastic creep, creep acceleration factor
o ***Excessive wear***; friction & lubrication – types of wear, vibration wear, material selection & hardness, wear acceleration factor
o ***Cyclic Fatigue***: Exact method for damage estimation (derivation using thermodynamic work)
o ***Miner's approximation*** – derivation, why it is an approx., stress concentration
o ***SN curves*** – material selection
o 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)
o ***PCB fatigue life*** - Circuit board component fatigue life model analysis –Steinberg Method (sine and random)
o ***Thermal cycle*** (strain, fatigue, acceleration factors derivations for Coffin-Manson & Modified, Norris-Landzberg
o Method of Combing Thermal & Vibration fatigue
Homework with Solutions

17. Physics of Failure 7 Step Problem Solving

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

19. Electronic & IC Physics of Failure Considerations
○ Thermal Cycle CTE Stress Issues
    ○ CTE's Mismatch, Thermal Fatigue
    ○ Engelmaier IPC Solder Joint Life Model, BGAs (Less time)
    ○ 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 (are we covering this?)
    ○ 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

Homework with Solutions

23. Putting it all Together