



LIFE CYCLE

RELIABILITY ENGINEERING

GUANGBIN YANG

CONTENTS

Preface	xi
1 Reliability Engineering and Product Life Cycle	1
1.1 Reliability Engineering, 1	
1.2 Product Life Cycle, 2	
1.3 Integration of Reliability Engineering into the Product Life Cycle, 5	
1.4 Reliability in the Concurrent Product Realization Process, 6 Problems, 7	
2 Reliability Definition, Metrics, and Product Life Distributions	9
2.1 Introduction, 9	
2.2 Reliability Definition, 10	
2.3 Reliability Metrics, 12	
2.4 Exponential Distribution, 17	
2.5 Weibull Distribution, 19	
2.6 Mixed Weibull Distribution, 22	
2.7 Smallest Extreme Value Distribution, 24	
2.8 Normal Distribution, 26	
2.9 Lognormal Distribution, 28 Problems, 31	

3	Reliability Planning and Specification	33
3.1	Introduction, 33	
3.2	Customer Expectations and Satisfaction, 34	
3.3	Reliability Requirements, 41	
3.4	Reliability Program Development, 48	
3.5	Reliability Design and Design for Six Sigma, 61 Problems, 64	
4	System Reliability Evaluation and Allocation	65
4.1	Introduction, 65	
4.2	Reliability Block Diagram, 66	
4.3	Series Systems, 68	
4.4	Parallel Systems, 71	
4.5	Mixed Configurations, 73	
4.6	k -out-of- n Systems, 77	
4.7	Redundant Systems, 79	
4.8	Reliability Evaluation of Complex Systems, 84	
4.9	Confidence Intervals for System Reliability, 91	
4.10	Measures of Component Importance, 99	
4.11	Reliability Allocation, 106 Problems, 118	
5	Reliability Improvement Through Robust Design	122
5.1	Introduction, 122	
5.2	Reliability and Robustness, 123	
5.3	Reliability Degradation and Quality Loss, 125	
5.4	Robust Design Process, 129	
5.5	Boundary Definition and Interaction Analysis, 132	
5.6	P-Diagram, 133	
5.7	Noise Effects Management, 134	
5.8	Design of Experiments, 136	
5.9	Experimental Life Data Analysis, 148	
5.10	Experimental Degradation Data Analysis, 152	
5.11	Design Optimization, 156	
5.12	Robust Reliability Design of Diagnostic Systems, 172	
5.13	Case Study, 179	
5.14	Advanced Topics in Robust Design, 181 Problems, 190	
6	Potential Failure Mode Avoidance	194
6.1	Introduction, 194	

6.2	Failure Mode and Effects Analysis, 195	
6.3	Advanced Topics in FMEA, 208	
6.4	Fault Tree Analysis, 212	
6.5	Advanced Topics in FTA, 225	
6.6	Computer-Aided Design Controls, 230	
	Problems, 235	
7	Accelerated Life Tests	237
7.1	Introduction, 237	
7.2	Development of Test Plans, 238	
7.3	Common Stresses and Their Effects, 246	
7.4	Life–Stress Relationships, 252	
7.5	Graphical Reliability Estimation at Individual Test Conditions, 266	
7.6	Analytical Reliability Estimation at Individual Test Conditions, 274	
7.7	Reliability Estimation at Use Condition, 292	
7.8	Compromise Test Plans, 302	
7.9	Highly Accelerated Life Tests, 326	
	Problems, 327	
8	Degradation Testing and Analysis	332
8.1	Introduction, 332	
8.2	Determination of the Critical Performance Characteristic, 333	
8.3	Reliability Estimation from Pseudolife, 334	
8.4	Degradation Analysis with Random-Effect Models, 337	
8.5	Degradation Analysis for Destructive Inspections, 345	
8.6	Stress-Accelerated Degradation Tests, 351	
8.7	Accelerated Degradation Tests with Tightened Thresholds, 358	
8.8	Accelerated Degradation Test Planning, 364	
	Problems, 373	
9	Reliability Verification Testing	379
9.1	Introduction, 379	
9.2	Planning Reliability Verification Tests, 380	
9.3	Bogey Testing, 383	
9.4	Sample Size Reduction by Tail Testing, 389	
9.5	Sequential Life Testing, 394	
9.6	Reliability Verification Using Prior Information, 406	
9.7	Reliability Verification Through Degradation Testing, 408	
	Problems, 410	

10	Stress Screening	412
10.1	Introduction, 412	
10.2	Screening Techniques, 413	
10.3	Design of Screen Plans, 415	
10.4	Principle of Degradation Screening, 417	
10.5	Part-Level Degradation Screening, 419	
10.6	Module-Level Screening, 425	
10.7	Module Reliability Modeling, 431	
10.8	Cost Modeling, 433	
10.9	Optimal Screen Plans, 435	
	Problems, 438	
11	Warranty Analysis	442
11.1	Introduction, 442	
11.2	Warranty Policies, 443	
11.3	Warranty Data Mining, 447	
11.4	Reliability Estimation from Warranty Claim Times, 451	
11.5	Two-Dimensional Reliability Estimation, 454	
11.6	Warranty Repair Modeling, 470	
11.7	Warranty Cost Estimation, 473	
11.8	Field Failure Monitoring, 477	
11.9	Warranty Cost Reduction, 480	
	Problems, 482	
	Appendix: Orthogonal Arrays, Linear Graphs, and	
	Interaction Tables	486
	References	495
	Index	511