

Contents

Preface	<u>xi</u>
Acknowledgments	<u>xiii</u>

CHAPTER 1

Introduction	<u>1</u>
Purpose of Accelerated Testing	<u>1</u>
Design Life	<u>2</u>
Statistical Sample Size Determination	<u>5</u>
Tolerances in Accelerated Testing	<u>5</u>
Financial Considerations	<u>8</u>
Response from Finance	<u>11</u>
Response from Engineering	<u>12</u>
Response from Manufacturing	<u>12</u>
Summary	<u>16</u>

CHAPTER 2

Probability Fundamentals	<u>17</u>
Sampling	<u>17</u>
Probability Density Function	<u>19</u>
Cumulative Distribution Function	<u>24</u>
Reliability Function	<u>25</u>
Hazard Function	<u>26</u>
Expectation	<u>27</u>
Summary	<u>29</u>

CHAPTER 3

Distributions	<u>31</u>
Continuous Modeling Distributions	<u>31</u>
Weibull Distribution	<u>32</u>
Normal Distribution	<u>37</u>
Lognormal Distribution	<u>43</u>
Exponential Distribution	<u>47</u>
Discrete Modeling Distributions	<u>51</u>
Poisson Distribution	<u>51</u>
Binomial Distribution	<u>53</u>
Hypergeometric Distribution	<u>54</u>
Geometric Distribution	<u>57</u>
Identifying the Correct Discrete Distribution	<u>58</u>
Sampling Distributions	<u>59</u>
Chi-Square Distribution	<u>59</u>
t -Distribution	<u>60</u>
F -Distribution	<u>62</u>
Bayes' Theorem	<u>64</u>
Summary	<u>67</u>

CHAPTER 4

Parameter Estimation	<u>69</u>
Maximum Likelihood Estimation	<u>70</u>
Probability Plotting	<u>70</u>
Hazard Plotting	<u>70</u>
Exponential Distribution	<u>71</u>
Maximum Likelihood Estimation	<u>71</u>
Hazard Plotting	<u>74</u>
Probability Plotting	<u>76</u>
Normal Distribution	<u>79</u>
Maximum Likelihood Estimation	<u>80</u>
Hazard Plotting	<u>83</u>
Probability Plotting	<u>84</u>
Lognormal Distribution	<u>87</u>

Weibull Distribution	<u>87</u>
Maximum Likelihood Estimation	<u>88</u>
Hazard Plotting	<u>90</u>
Probability Plotting	<u>92</u>
Nonparametric Confidence Intervals	<u>96</u>
Summary	<u>96</u>

CHAPTER 5

Accelerated Test Plans	<u>97</u>
Mean Time to Fail	<u>97</u>
Test Plan Problems	<u>98</u>
Zero-Failure Testing	<u>103</u>
Bogey Testing	<u>103</u>
Bayesian Testing	<u>103</u>
Effect of the Shape Parameter	<u>103</u>
Estimating the Shape Parameter	<u>106</u>
Determining Test Parameters	<u>106</u>
Guidelines for Zero-Failure Test Planning	<u>108</u>
Sequential Testing	<u>111</u>
Pass-Fail Testing	<u>111</u>
Exponential Distribution	<u>116</u>
Weibull Distribution	<u>118</u>
Randomization of Load Cycles	<u>122</u>
Reliability Growth	<u>124</u>
Reliability Growth Process	<u>125</u>
Reliability Growth Models	<u>126</u>
Duane Model	<u>126</u>
AMSAA Model	<u>128</u>
Summary	<u>130</u>

CHAPTER 6

Accelerated Testing Models	<u>131</u>
Linear Acceleration	<u>131</u>
Field Correlation	<u>132</u>
Arrhenius Model	<u>138</u>

Eyring Model	<u>145</u>
Voltage Models	<u>155</u>
Mechanical Crack Growth	<u>156</u>
Degradation Testing	<u>157</u>
Qualitative Tests	<u>162</u>
Step-Stress Testing	<u>162</u>
Elephant Tests	<u>163</u>
HALT and HASS	<u>164</u>
Summary	<u>165</u>

CHAPTER 7

Environmental Stress Screening	<u>167</u>
Stress Screening Theory	<u>167</u>
Product Reliability Equation	<u>168</u>
What Is ESS?	<u>170</u>
Evolution of ESS	<u>170</u>
Misconceptions about ESS	<u>172</u>
Types of Environmental Stress	<u>173</u>
Temperature Cycling	<u>173</u>
Random Vibration	<u>176</u>
High-Temperature Burn-In	<u>177</u>
Electrical Stress	<u>177</u>
Thermal Shock	<u>177</u>
Sine Vibration, Fixed Frequency	<u>178</u>
Low-Temperature Screen	<u>178</u>
Sine Vibration, Swept Frequency	<u>178</u>
Combined Environment	<u>178</u>
Advantages of Temperature Cycling	<u>178</u>
Levels of Screen Complexity	<u>181</u>
Failure Analysis	<u>182</u>
Case Histories	<u>182</u>
Analogic Corporation	<u>182</u>
Bendix Corporation	<u>183</u>
Hewlett-Packard (HP)	<u>183</u>
Implementing an ESS Program	<u>183</u>
Equipment	<u>186</u>
Burn-In Optimization	<u>187</u>
Summary	<u>189</u>

CHAPTER 8

Test Equipment Methods and Applications	<u>191</u>
Simulation versus Stimulation	<u>193</u>
Simulation	<u>193</u>
Application	<u>193</u>
Typical Test Types	<u>193</u>
Defining the Real World	<u>193</u>
Stimulation	<u>195</u>
Application	<u>195</u>
Typical Test Types	<u>196</u>
Types of Stresses	<u>196</u>
Temperature	<u>196</u>
Steady State	<u>196</u>
Temperature Cycling	<u>197</u>
Thermal Shock	<u>197</u>
Vibration	<u>198</u>
Analysis Tools	<u>198</u>
Mechanical and Pneumatic	<u>199</u>
Loose Cargo Testing	<u>199</u>
Cyclic Testing	<u>199</u>
Electrodynamic	<u>200</u>
Hydraulic	<u>200</u>
Mechanical Shock	<u>201</u>
Electrical Stress	<u>202</u>
Combined Environments	<u>202</u>
Other Types of Stress	<u>202</u>
Summary	<u>203</u>
Appendix A: Statistical Tables	<u>205</u>
Appendix B: Government Documents	<u>217</u>
Appendix C: Glossary	<u>219</u>
Appendix D: List of Acronyms	<u>225</u>
Bibliography	<u>227</u>
About the Authors	<u>229</u>
Index	<u>231</u>