
Contents

Foreword 1	xi
Foreword 2	xv
Preface	xix
Chapter 1. Accelerated Life Testing	1
Laurent DENIS, Henri GRZESKOWIAK, Daniel TRIAS and David DELAUX	
1.1. Introduction	1
1.2. Types of test	2
1.2.1. Calculations.	2
1.2.2. Simulations	2
1.2.3. Tests.	3
1.2.4. Links between three types of demonstration.	4
1.3. Overview of accelerated life testing.	5
1.3.1. Statistical models.	7
1.3.2. Physical models	8
1.4. Principles, methodology, implementation of accelerated life testing	8
1.4.1. Definition and important concepts	8
1.4.2. Evaluating the predicted reliability of a system by performing tests	11
1.4.3. Accelerated life tests (based on a physical model): example of temperature acceleration	13
1.4.4. Evaluating the predicted reliability of a system for a given lifetime and with given environmental constraints	13

1.4.5. Damp heat	15
1.4.6. Temperature	16
1.4.7. Accelerated life testing in practice	17
1.4.8. Reliability assessment to find wear-related failure mechanisms	17
1.4.9. Conclusion.	18
1.5. Methods and tools for exploiting accelerated life tests	19
1.5.1. SDA or survival data analysis	19
1.5.2. Data types	20
1.5.3. Model fitting	24
1.5.4. Deterioration	27
1.5.5. ALM or accelerated life models	31
1.6. Phases in the construction of a reliability validation plan	36
1.7. Examples	38
1.7.1. Example 1	38
1.7.2. Development of a climate corrosion test for an automobile heat exchanger.	42
1.8. Standards	51
1.9. Conclusion	52
1.10. Bibliography	52
Chapter 2. Highly Accelerated Testing	57
Henri GRZESKOWIAK, Tony LHOMMEAU and David DELAUX	
2.1. Introduction to highly accelerated testing	57
2.1.1. History	58
2.1.2. General approach	59
2.1.3. Robustness and reliability	62
2.1.4. Types of products for which highly accelerated testing is relevant.	65
2.1.5. Example in the aerospace sector.	68
2.1.6. Types of defects triggered by HALT tests	71
2.1.7. Analysis of tests by a HALT machine with pneumatic hammers: special features and inherent precautions	81
2.2. Comparison of HALT versus ALT testing by fatigue	87
2.2.1. The fatigue damage spectrum	88
2.2.2. Automobile case study: breakage of a converter/inverter	92
2.3. Comparison of accelerated life tests and highly accelerated tests	103
2.4. Standards	104
2.5. Bibliography	105

Chapter 3. Reliability Study for Cuboid Aluminum Capacitors with Liquid Electrolyte	109
Chadia LACHKAR, Moncef KADI, Jean-Paterne KOUADIO, Jean-François GOUPY, Philippe EUDELINÉ, Sébastien BOILEAU and Tarik AIT-YOUNES	
3.1. Introduction and objectives	109
3.2. Characteristics of aluminum capacitors with liquid electrolyte	110
3.2.1. Basic principle	110
3.2.2. Cuboid-shaped geometry	112
3.2.3. Equivalent electrical circuit	112
3.2.4. Electrical characteristics	113
3.2.5. Physical characteristics	114
3.3. Parametric characterization	115
3.3.1. Measuring C, ESR and DF	115
3.3.2. Measuring the leakage current	115
3.3.3. Measuring the dimensions of capacitor's case	116
3.3.4. Other measurements and observations	116
3.3.5. Use of measurements	117
3.4. Reliability analysis	117
3.4.1. Specific objectives	117
3.4.2. Functional mission profile	118
3.4.3. Environmental mission profile	119
3.4.4. Deterioration mechanisms	119
3.5. Aging tests on components	120
3.5.1. Test series	122
3.5.2. Thermal tests	124
3.5.3. Thermoelectric tests	126
3.5.4. Summary of test results	130
3.6. Analysis and modeling	130
3.6.1. Influence of temperature	130
3.6.2. Thermoelectric influences	132
3.7. Conclusion and continuation	134
3.8. Appendix: notice aluminum electrolytic capacitor	135
3.9. Bibliography	136
Chapter 4. The Reliability of Components: A New Generation of Film Capacitors	139
Henri GRZESKOWIAK, Daniel TRIAS and David DELAUX	
4.1. Introduction	139

4.2. The reliability of components: a new generation of film capacitors. Types of film	140
4.2.1. Polypropylene	140
4.2.2. Polyethylene terephthalate	140
4.2.3. Polyethylene naphthalate (PEN)	141
4.2.4. Polyphenylene sulfide	141
4.2.5. Teflon (PTFE).	142
4.3. Comparison	142
4.4. Parameters that affect the reliability	143
4.4.1. Self-healing (metalized films only)	143
4.4.2. Corona effect	144
4.4.3. Humidity and corrosion	144
4.5. Highly accelerated test on film capacitors.	145
4.6. Accelerated life test on film capacitors	148
4.6.1. Design of the accelerated life test	149
4.6.2. Analysis after conducting the accelerated life test	151
4.7. Conclusions	152
4.8. Bibliography	153
Chapter 5. Reliability and Qualification Tests for High-Power MOSFET Transistors	155
Niemat MOULTIF, Mohamed MASMOUDI, Eric JOUBERT and Olivier LATRY	
5.1. Introduction	155
5.2. Reliability tests for high-power MOSFET transistors	157
5.2.1. Technology tests: failure mechanisms of high-power MOSFETs	157
5.2.2. Qualification tests and standards	159
5.3. Application of standard reliability tests to high-power silicon MOSFETs.	164
5.3.1. Description of tested components	164
5.3.2. High-temperature reverse bias	166
5.3.3. Electrostatic discharges.	173
5.4. Application of qualification tests to high-power SiC MOSFETs	180
5.4.1. Presentation of the tested component: MOSFET SiC	180
5.4.2. HTRB and HTGB tests.	181
5.4.3. Study of the robustness of SiC MOSFETs with respect to electrostatic discharge	188

5.5. Conclusion.	193
5.6. Bibliography.	195
Chapter 6. Fault Diagnosis in a DC/DC Converter for Electric Vehicles	199
Houcine CHAFOUK and Rihab El Houda THABET	
6.1. Introduction	199
6.2. Model of the DC/DC converter	202
6.2.1. Model without uncertainty	203
6.2.2. LPV model with bounded uncertainties	204
6.3. General-purpose methodology for determining and isolating defects	205
6.3.1. Theoretical basis of the observer	205
6.3.2. Fault detection by the observer	208
6.3.3. Interval observer	209
6.3.4. Interval residual	214
6.3.5. Signature analysis: detection and location	214
6.4. Conclusion.	218
6.5. Bibliography.	218
Chapter 7. Methodology and Physicochemical Characterization Techniques Used for Failure Analysis in Laboratories	221
Morgane PRESLE, Daniel TRIAS and Sébastien BOILEAU	
7.1. Introduction	221
7.2. Failure analysis of electronic components	222
7.2.1. Concepts of failure analysis	222
7.2.2. Failures of film capacitors.	223
7.2.3. Electrochemical capacitor failures	224
7.2.4. Failure analysis methodology	225
7.3. Experimental techniques of physicochemical analysis	227
7.3.1. Preopening examinations	227
7.3.2. Postopening examinations.	230
7.4. Conclusion.	239
7.5. Bibliography.	240
Chapter 8. Reliability Study of High-Power Mechatronic Components by Spectral Photoemission Microscopy	241
Niemat MOULTIF, Alexis DIVAY, Eric JOUBERT and Olivier LATRY	
8.1. Introduction	241
8.2. Conventional techniques for locating faults	243
8.2.1. Liquid crystal.	243

8.2.2. Infrared microscopy	244
8.2.3. Laser stimulation techniques.	245
8.2.4. Photoemission microscopy.	248
8.3. Spectral photoemission analysis	256
8.3.1. Existing spectral photoemission analysis systems	256
8.3.2. Description of the system	257
8.4. Transistor analysis by spectral photoemission microscopy	260
8.4.1. Reliability study of AlGaIn/GaN HEMT transistors	260
8.4.2. Reliability study of high-power silicon carbide MOSFET transistors	263
8.5. Conclusion	268
8.6. Bibliography	269
List of Authors	273
Index	275