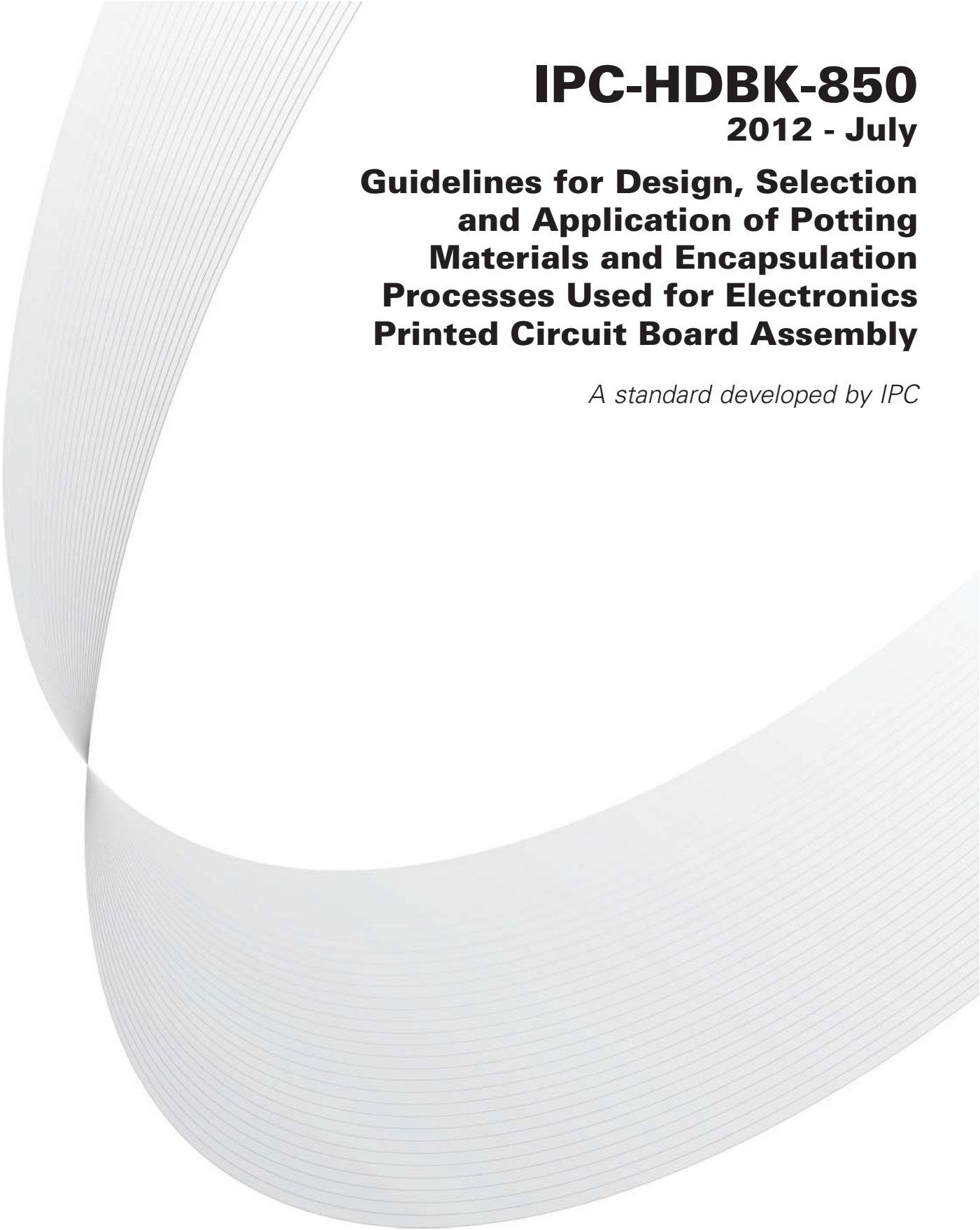




IPC-HDBK-850

2012 - July

Guidelines for Design, Selection and Application of Potting Materials and Encapsulation Processes Used for Electronics Printed Circuit Board Assembly

A standard developed by IPC

Association Connecting Electronics Industries



This is a preview. [Click here to purchase the full publication.](#)

The Principles of Standardization

In May 1995 the IPC's Technical Activities Executive Committee (TAEC) adopted Principles of Standardization as a guiding principle of IPC's standardization efforts.

Standards Should:

- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:

- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

Notice

IPC Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such Standards and Publications shall not in any respect preclude any member or nonmember of IPC from manufacturing or selling products not conforming to such Standards and Publication, nor shall the existence of such Standards and Publications preclude their voluntary use by those other than IPC members, whether the standard is to be used either domestically or internationally.

Recommended Standards and Publications are adopted by IPC without regard to whether their adoption may involve patents on articles, materials, or processes. By such action, IPC does not assume any liability to any patent owner, nor do they assume any obligation whatever to parties adopting the Recommended Standard or Publication. Users are also wholly responsible for protecting themselves against all claims of liabilities for patent infringement.

IPC Position Statement on Specification Revision Change

It is the position of IPC's Technical Activities Executive Committee that the use and implementation of IPC publications is voluntary and is part of a relationship entered into by customer and supplier. When an IPC publication is updated and a new revision is published, it is the opinion of the TAEC that the use of the new revision as part of an existing relationship is not automatic unless required by the contract. The TAEC recommends the use of the latest revision. Adopted October 6, 1998

Why is there a charge for this document?

Your purchase of this document contributes to the ongoing development of new and updated industry standards and publications. Standards allow manufacturers, customers, and suppliers to understand one another better. Standards allow manufacturers greater efficiencies when they can set up their processes to meet industry standards, allowing them to offer their customers lower costs.

IPC spends hundreds of thousands of dollars annually to support IPC's volunteers in the standards and publications development process. There are many rounds of drafts sent out for review and the committees spend hundreds of hours in review and development. IPC's staff attends and participates in committee activities, typesets and circulates document drafts, and follows all necessary procedures to qualify for ANSI approval.

IPC's membership dues have been kept low to allow as many companies as possible to participate. Therefore, the standards and publications revenue is necessary to complement dues revenue. The price schedule offers a 50% discount to IPC members. If your company buys IPC standards and publications, why not take advantage of this and the many other benefits of IPC membership as well? For more information on membership in IPC, please visit www.ipc.org or call 847/597-2872.

Thank you for your continued support.



IPC-HDBK-850

Guidelines for Design, Selection and Application of Potting Materials and Encapsulation Processes Used for Electronics Printed Circuit Board Assembly

Developed by the Potting and Encapsulation Task Group (5-33f) of the
Cleaning and Coating Committee (5-30) of IPC

Users of this publication are encouraged to participate in the
development of future revisions.

Contact:

IPC
3000 Lakeside Drive, Suite 309S
Bannockburn, Illinois
60015-1249
Tel 847 615.7100
Fax 847 615.7105

This is a preview. [Click here to purchase the full publication.](#)

This Page Intentionally Left Blank

Acknowledgment

Any document involving a complex technology draws material from a vast number of sources. While the principal members of the Potting and Encapsulation Task Group (5-33f) of the Cleaning and Coating Committee (5-30) are shown below, it is not possible to include all of those who assisted in the evolution of this handbook. To each of them, the members of the IPC extend their gratitude.

Cleaning and Coating Committee	Potting and Encapsulation Task Group	Technical Liaisons of the IPC Board of Directors
Chair Douglas O. Pauls Rockwell Collins	Chair Barry Ritchie Dow Corning Corporation	Dongkai Shangguan Flextronics International
Vice Chair Debora L. Obitz Trace Laboratories - Baltimore	Vice Chair Gordon Sullivan Royal Adhesives & Sealants	Shane Whiteside TTM Technologies
Potting and Encapsulation Task Group		
Patrick Redmond, Boeing Company	Jeff Labodda, Epic Resins	Amy Hagnauer, Raytheon Company
Jason Keeping, Celestica	Jonathon Zarnstorff, Epic Resins	Bill Vuono, Raytheon Company
Greg Vorhis, Coastal Technical Services	Mike Seluke, EXACT Dispensing Systems by Sheepscot Machine Works	Fonda Wu, Raytheon Company
Brian Madsen, Continental Automotive Systems	Todd Williams, EXACT Dispensing Systems by Sheepscot Machine Works	Martin Scionti, Raytheon Missile Systems
Stan Rak, Continental Automotive Systems	Richard Stadem, General Dynamics Advanced Information Systems	Nate Grinvalds, Rockwell Collins
Karen Tellefsen, Cookson Electronics	David Edwards, Henkel Corporation	Douglas Pauls, Rockwell Collins
Anitha Sinkfield, Delphi Electronics and Safety	Jeffrey Sargeant, HumiSeal Division of Chase Corporation	Gordon Sullivan, Royal Adhesives & Sealants
Carlos Montemayor, Dow Corning Corporation	John Waryold, HumiSeal Division of Chase Corporation	Stephen Craig, Shin-Etsu Silicones of America, Inc.
Barry Ritchie, Dow Corning Corporation	Rudiger Dietrich, Lackwerke Peters GmbH & Co KG	Kim Atkins, Specialized Coating Services
Anne Lomonte, Draeger Medical Systems, Inc.	Michael Green, Lockheed Martin Space Systems Company	Rick Ramirez, Specialized Coating Services
Jonathan Galaska, Dymax Corporation	Hue Green, Lockheed Martin Space Systems Company	Stephen Meeks, St. Jude Medical
Michael Suwe, ELANTAS Beck GmbH	Richard Litavis, Paradigm Inc.	Debora Obitz, Trace Laboratories - Baltimore
Robert Phelps, ELANTAS PDG, INC.	Paula Vandenberg, Plasma Ruggedized Solutions	John Radman, Trace Laboratories - Denver
James Stockhausen, ELANTAS PDG, INC.	Richard Kraszewski, Plexus Corporation	Bruce Hughes, U.S. Army Aviation & Missile Command
Jade Bridges, Electrolube	Bill Barthel, Plexus Manufacturing Solutions	Bhanu Sood, University of Maryland
Amanda Stuart, Electrolube		Ray Simon
Arthur Perkowski, Electronic Coating Technologies Inc.		Sal Sparacino, ZESTRON America
		Umut Tosun, ZESTRON America

This Page Intentionally Left Blank

Table of Contents

1 SCOPE	1	3.3.6 Q-Resonance	23
1.1 Introduction	1	3.3.7 Dielectric Constant and Dissipation Factor	23
1.2 Purpose	1	3.4 Processing Characteristics	23
1.3 Scope	1	3.4.1 Viscosity	23
1.4 Terms and Definitions	1	3.4.2 Thixotropy	24
1.4.1 Material Terms and Definitions	2	3.4.3 Curing Exotherms	25
1.4.2 Application Terms and Definitions	4	3.4.4 Work Time (Pot Life)	25
2 APPLICABLE DOCUMENTS	14	3.5 Selecting a P/E Material	25
2.1 ASTM	14	3.5.1 Select with End Environment in Mind	25
2.2 IPC Standards	14	3.5.2 Design for Encapsulation Application	25
2.3 Joint Industry Standard	14	3.5.3 Design Philosophy	26
2.4 Military Standards	14	3.6 Qualifying a P/E Material	27
2.5 Underwriters Laboratories	15	3.6.1 Vendor's Data Sheet	27
2.6 British Standards (DSTAN, UK Defense Standardization)	15	3.6.2 Compatibility with Process Materials	27
2.7 IEC Standards	15	3.6.3 Residues Related to PCB and Components	27
2.8 Federal Standards	15	3.6.4 Component Material Types	28
3 P/E MATERIALS	15	4 ELECTRICAL CONSIDERATIONS	30
3.1 Chemistry Types	15	4.1 High Voltage (HV)/High Current (HC)	30
3.1.1 Polyurethane and Polysulfide	15	4.2 RF and Microwave	31
3.1.2 Epoxy	16	4.3 High Speed Digital	31
3.1.3 Acrylics	16	4.4 Controlled Impedance	31
3.1.4 Silicone	17	4.5 EMI/ESD	31
3.1.5 UV/Visible Light Cure	17	4.5.1 EMI (Electromagnetic Interference)	31
3.1.6 Others Chemistry Types	17	4.5.2 ESD (Electrostatic Discharge)	31
3.2 Discussion of Properties	17	4.6 Encapsulation Coverage	31
3.2.1 Chemical Resistance	17	4.7 Masking	31
3.2.2 Thermal Characteristics	18	4.8 Drawings and Design Guidelines	31
3.2.3 Outgassing	18	4.9 Chemical Susceptibility Testing	31
3.2.4 Shrinkage/Residual Stress	19	4.10 Accelerated Aging Tests	32
3.2.5 Adhesion	19	4.11 Validating a P/E Material	32
3.2.6 Coefficient of Thermal Expansion (CTE)	20	4.12 Discussion of Material Properties and Dependence on Processing Methods	32
3.2.7 Hardness	20	4.12.1 Encapsulation Properties	32
3.2.8 Green Strength	20	4.12.2 Appearance/Color	32
3.2.9 Young's Modulus	20	4.12.3 Dielectric Properties	32
3.2.10 Glass Transition Temperature (T_g)	20	4.12.4 Dielectric Withstanding Voltage	32
3.3 Electrical	23	4.12.5 Dielectric Insulation Resistance	32
3.3.1 Insulation Characteristics	23	4.12.6 Dielectric Q-Resonance	32
3.3.2 Dielectric Properties	23	4.12.7 Dielectric Constant and Dissipation Factor	32
3.3.3 Dielectric Withstanding Voltage (DWV)	23	4.12.8 Thermal Properties	33
3.3.4 Insulation Resistance	23	4.12.9 Thermal Stability	33
3.3.5 Moisture and Insulation Resistance (M and IR)	23	4.12.10 Flammability	34
		4.12.11 Flexibility	34

4.12.12	Abrasion Resistance	34	6.7	Nuclear Biological Chemical Warfare Environment	42
4.12.13	Hydrolytic Stability	34	7	LONG TERM RELIABILITY AND TESTING	42
4.12.14	Permeability	34	7.1	Failure Mechanism	42
4.12.15	Chemical Compatibility and Chemical Resistance	35	7.1.1	Wear/Abrasion	42
4.12.16	Chemical Resistance	35	7.1.2	Loss of Transparency/Discoloration	42
4.12.17	Biological Compatibility	35	7.1.3	Cracking	42
4.12.18	Vapor Resistance	35	7.1.4	Loss of Adhesion	42
4.12.19	Corrosion Resistance	35	7.1.5	Bubbles	43
4.12.20	Fungus Resistance	35	7.1.6	Blistering	43
4.12.21	UV Stability	36	7.1.7	Charring	43
4.12.22	Radiation Resistance	36	7.1.8	Degradation	43
4.12.23	Outgassing	36	7.1.9	Chemical Attack	43
5	REWORK AND REPAIR	36	7.2	Accelerated Testing	43
5.1	Removal Methods	36	7.2.1	Test Parameters	43
5.1.1	Chemical	36	7.2.2	Examples of Tests	44
5.1.2	Mechanical Abrasion	37	8	EQUIPMENT CONSIDERATIONS	44
5.1.3	Media Blasting	37	8.1	Mixing	44
5.1.4	Dry Ice Abrasion	37	8.1.1	Static Mix	44
5.1.5	Thermal Degradation	37	8.1.2	Dynamic Mixing	44
5.1.6	Laser	37	8.1.3	Spinning Mixers	44
5.1.7	Plasma	37	8.1.4	Pin Mixers	44
5.1.8	Combination Rework Methods	38	8.2	Dispensing	44
5.2	Cleaning after Stripping	38	8.2.1	Highly Filled Materials	44
5.3	Re-Encapsulation	38	8.2.2	Abrasivity of Fillers	45
5.4	Environmental, Health and Safety Rework and Repair Considerations	39	8.2.3	Filler Selection	45
6	END USE ENVIRONMENT	39	8.2.4	Maintenance Considerations	45
6.1	Outdoor Environment	39	8.2.5	Polyurethanes Containing Isocyanates	45
6.1.1	Ultraviolet (UV) Radiation	39	8.2.6	Displacement System Size	45
6.1.2	Humidity	39	9	DESIGN CONSIDERATIONS IN P/E	45
6.1.3	Pollutant Gases	39	9.1	Intended Function in the End Use Environment	45
6.1.4	Ozone	39	9.2	Residual Stress Effects on Components	45
6.1.5	Acid Rain	40	9.3	Sleeving	45
6.1.6	Marine and Coastal Environment	40	9.4	LEDs	45
6.2	Automotive	40	9.5	Inappropriate Uses of P/E Materials	46
6.3	Avionics Environment	41	9.6	Part Geometries	46
6.3.1	Aircraft on the Ground	41	10	ENCLOSURE CONSIDERATIONS	46
6.3.2	Equipment Outside the Pressure Contain- ment Compartment During Operations	41	10.1	Component Density	46
6.3.3	Equipment Inside the Pressure Contain- ment Compartment During Operations	41	10.2	Clearances	46
6.4	Space Environment	41	10.3	Vent Holes	46
6.5	Medical Environment	41	10.4	Surface Texture/Surface Energy of Enclosures/Substrates	46
6.6	Geothermal Environment	41	11	PREPARATION FOR P/E	46
			11.1	Material Storage	46

11.2	Substrate Preparation	46	13.10.1	Exotherm	56
11.3	Surface Residues and Impact on P/E	47	13.11	Shrinkage	56
11.3.1	Residual Fluxes	47	13.12	Premature Surface Cure/Solvent Entrapment	56
11.3.2	Adhesives	47	13.13	Exceeding Cure Recommendations	57
11.3.3	Primers	47	14	APPLICATION PROCESS MONITORING	57
11.3.4	Priming for Acrylics	48	14.1	Inspection Guidelines	57
11.3.5	Priming for Urethane	48	14.2	Monitoring a P/E Process	57
11.3.6	Priming for Polysulfide	48	14.2.1	Workmanship	57
11.3.7	Plasma Treatment	48	14.2.2	Oven Profiling	57
11.3.8	Mechanical Etching	49	14.2.3	Volumetric Shot Size	57
11.4	Masking	49	14.2.4	Weight	57
11.4.1	Types of Masks	49	14.2.5	Hardness	57
11.4.2	Manual vs. Automated Masking	50	15	ENVIRONMENTAL, HEALTH AND SAFETY PROCESSING CONSIDERATIONS	58
11.5	Preheats	50	15.1	Environmental Health and Safety Viscosity Adjustment	58
11.6	Molds and Containers	50	15.2	Curing Ventilation Considerations	58
11.6.1	Waxes	50	15.3	Workplace Considerations	58
11.6.2	Porous Containers	50	15.4	Exotherms Dependent on Volume of Material	58
11.6.3	Mold Release Agents	50	16	INHIBITION	58
11.7	Mixing and Preparing Materials	50	16.1	Interfacial Inhibition	59
11.7.1	Hand Mixing (Cups)	50	16.2	Mild Inhibition	59
11.7.2	Automated Mixing on the Fly	52	16.3	Gross Inhibition	59
11.7.3	Proper Mix Ratio	52	16.4	Location of Inhibition	59
11.7.4	Vacuum Degassing of Mixed Materials	52	16.5	Causes of Inhibition	59
12	DISPENSING	53	16.6	Compatibility Check List	59
12.1	Pouring	53	16.7	Adhesion	60
12.1.1	Positive Displacement Piston Metering	54	16.8	Solder Mask/Substrate	60
12.1.2	Injection Molding	54	16.9	Components	60
12.1.3	Dipping	54	16.10	Surface Finishes	60
12.1.4	Brushing	54	16.11	Cleanliness	60
12.1.5	Spraying	54	16.12	Interlayer Adhesion	61
12.1.6	Dispensing Under Vacuum	54	17	POTTING/COATING OVER ENCAPSULANTS	61
12.2	After Dispensing	54	17.1	Mixed Hardness Systems	61
12.2.1	Degassing the Assembly	54	17.2	Interlayer Adhesion	61
12.2.2	Wait Periods and Exotherms	54	17.3	Compatibility with Process Materials	61
13	CURE MECHANISMS	55	18	MATERIALS RELATED TO LEAD FREE PROCESSING THAT AFFECT P/E	62
13.1	Heat Cure	55	18.1	Materials that Leach from Substrates at Higher Temperature	62
13.2	Heat Accelerable	55	18.2	Changes in Surface Energy of Substrates	62
13.3	Vacuum Bake	55	18.3	Glycols from Solder Masks	62
13.4	Under Pressure	55	18.4	Flux/Paste Residues are More Aggressive	62
13.5	Humidity	55			
13.6	Room Temperature Cure	55			
13.7	UV/Visible Light	55			
13.8	Catalytic Cure	56			
13.9	Cure Process Considerations	56			
13.10	Cure By-Products	56			