IPC-6013B

Qualification and Performance Specification for Flexible Printed Boards

Developed by the Flexible Circuits Performance Specifications Subcommittee (D-12) of the Flexible Circuits Committee (D-10) of IPC

Supersedes:
IPC-6013A with Amendment 2 - April 2006
IPC-6013A with Amendment 1 - January 2005
IPC-6013A - November 2003
Amendment 1 - December 2005
IPC-6013 with Amendment 1
Includes:
IPC-6013 - November 1998
Amendment 1 - April 2000
IPC-RF-245 - April 1987
IPC-FC-250A - January 1974

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

Contact:

IPC
3000 Lakeside Drive, Suite 309S
Bannockburn, Illinois
60015-1219
Tel 847 615.7100
Fax 847 615.7105

Table of Contents

1 **SCOPE** 1
1.1 Statement of Scope 1
1.2 Purpose 1
1.3 Performance Classification, PB Type, and Installation Usage 1
1.3.1 Classification 1
1.3.2 PB Type 1
1.3.3 Installation Uses 1
1.3.4 Selection for Procurement 1
1.3.5 Material, Plating Process and Final Finish 1
1.4 Terms and Definitions 2
1.4.1 As Agreed Upon Between User and Supplier (AABUS) 2
1.4.2 Coverlay 2
1.4.3 Coverfilm 2
1.4.4 Covercoat 2
1.4.5 Cover Material 3
1.5 Interpretation ''Shall'' 3
1.6 Presentation 3
1.7 Revision Level Changes 3

2 **APPLICABLE DOCUMENTS** 3
2.1 IPC 3
2.2 Joint Industry Standards 4
2.3 Other Publications 4
2.3.1 American Society for Testing and Materials 4
2.3.2 National Electrical Manufacturers Association 4
2.3.3 American Society for Quality 4
2.3.4 AMS 4
2.3.5 American Society of Mechanical Engineers 4
2.3.6 Federal 4

3 **REQUIREMENTS** 4
3.1 General 4
3.2 Materials Used in this Specification 5
3.2.1 Laminates and Bonding Materials 5
3.2.2 External Bonding Materials 5
3.2.3 Other Dielectric Materials 5
3.2.4 Metal Foils 5
3.2.5 Metal Planes/Cores 5
3.2.6 Metallic Platings and Coatings 5
3.2.7 Organic Solderability Protective Coatings (OSP) 7
3.2.8 Polymer Coating (Solder Mask) 7
3.2.9 Fusing Fluids and Fluxes 7
3.2.10 Marking Inks 7
3.2.11 Hole Fill Insulation Material 8
3.2.12 Heatsink Planes, External 8
3.2.13 Via Protection 8
3.2.14 Embedded Passive Materials 8
3.3 Visual Examination 8
3.3.1 Profile 8
3.3.2 Construction Imperfections 8
3.3.3 Plating and Coating Voids in the Hole 11
3.3.4 Lifted Lands 11
3.3.5 Marking 11
3.3.6 Solderability 12
3.3.7 Plating Adhesion 12
3.3.8 Edge Board Contact, Junction of Gold Plate to Solder Finish 12
3.3.9 Workmanship 12
3.4 Dimensional Requirements 13
3.4.1 Hole Size, Hole Pattern Accuracy and Pattern Feature Accuracy 13
3.4.2 Annular Ring and Breakout (External) 13
3.4.3 Bow and Twist (Individual Rigid or Stiffener Portions Only) 15
3.5 Conductor Definition 16
3.5.1 Conductor Width and Thickness 16
3.5.2 Conductor Spacing 16
3.5.3 Conductor Imperfections 16
3.5.4 Conductive Surfaces 17
3.6 Structural Integrity 18
3.6.1 Thermal Stress Testing 18
3.6.2 Requirements for Microsectioned Coupons or Production PBs 19
3.7 Solder Mask Requirements 26
3.7.1 Solder Mask Coverage 26
3.7.2 Solder Mask Cure and Adhesion 27
3.7.3 Solder Mask Thickness 27
3.8 Electrical Requirements 27
3.8.1 Dielectric Withstanding Voltage 27
3.8.2 Electrical Continuity and Isolation Resistance 27
3.8.3 Circuit/PTH Shorts to Metal Substrates 28
3.8.4 Moisture and Insulation Resistance (MIR) 28
3.9 Cleanliness 28

3.9.1 Cleanliness Prior to Solder Mask Application 28
3.9.2 Cleanliness After Solder Mask, Solder, or Alternative Surface Coating Application 28
3.9.3 Cleanliness of Inner Layers After Oxide Treatment Prior to Lamination 28
3.10 Special Requirements 29
3.10.1 Outgassing 29
3.10.2 Organic Contamination 29
3.10.3 Fungus Resistance 29
3.10.4 Vibration 29
3.10.5 Mechanical Shock 29
3.10.6 Impedance Testing 29
3.10.7 Coefficient of Thermal Expansion (CTE) 29
3.10.8 Thermal Shock 29
3.10.9 Surface Insulation Resistance (As Received) 29
3.10.10 Metal Core (Horizontal Microsection) 30
3.10.11 Ionic (Resistivity of Solvent Extract) 30
3.10.12 Rework Simulation 30
3.10.13 Bending Test 30
3.10.14 Flexible Endurance 30
3.10.15 Bond Strength (Unsupported Lands) 31
3.10.16 Bond Strength (Stiffener) 31
3.11 Repair 31
3.11.1 Circuit Repair 31
3.12 Rework 31

4 QUALITY ASSURANCE PROVISIONS 31
4.1 General 31
4.1.1 Qualification 31
4.1.2 Sample Test Coupons 31
4.2 Acceptance Testing and Frequency 34
4.2.1 C=0 Zero Acceptance Number Sampling Plan 34
4.2.2 Referee Tests 38
4.3 Quality Conformance Testing 38
4.3.1 Coupon Selection 38

5 NOTES 38
5.1 Ordering Data 38
5.2 Superseded Specifications 38

APPENDIX A 39

Figures

Figure 3-1 Transition Zone 9
Figure 3-2 Unacceptable Covercoat Coverage 10
Figure 3-3 Solder Wicking and Plating Penetration 11
Figure 3-4 Annular Ring Measurement (External) 14
Figure 3-5 Breakout of 90° and 180° 14
Figure 3-6 Conductor Width Reduction 14
Figure 3-7 Major and Minor Access Holes for Flexible PBs with Tangency Allowance 15
Figure 3-8 Squeeze-Out of Cover Film Adhesive and Ooze-Out of Covercoat 15
Figure 3-9 Missing Material or Skips in the Bead of Adhesive Squeeze-Out at Coverlay Edges 16
Figure 3-10 Unnecessary Copper Between Conductor and Nodule of Conductor 16
Figure 3-11 Rectangular Surface Mount Lands 17
Figure 3-12 Round Surface Mount Lands 17
Figure 3-13 Separation at External Foil 20
Figure 3-14 Crack Definition 20
Figure 3-15 Typical Microsection Evaluation Specimen 21
Figure 3-16 Etchback Depth Allowance 22
Figure 3-17 Smear Removal Allowance 22
Figure 3-18 Negative Etchback 22
Figure 3-19 Plating Folds/Inclusions 23
Figure 3-20 Annular Ring Measurement (Internal) 23
Figure 3-21 Microsection Rotations for Breakout Detection 24
Figure 3-22 Comparison of Microsection Rotations 24
Figure 3-23 Surface Copper Wrap Measurement (Applicable to all filled PTHs) 24
Figure 3-24 Wrap Copper in Type 4 PB (Acceptable) 24
Figure 3-25 Wrap Copper Removed by Excessive Sanding/Planarization (Not Acceptable) 25
Figure 3-26 Metal Core to Plated-Through Hole Spacing 26
Figure 3-27 Measurement of Minimum Dielectric Spacing 26
Figure 3-28 Bending Test 30

Tables

Table 1-1 Default Requirements 2
Table 3-1 Internal or External Metal Planes 5
Table 3-2 Final Finish, Coating and Copper Plating Requirements 6
Table 3-3 Covercoat Adhesion 11
Table 3-4 Solder Wicking/Plating Penetration Limits 11

Table 3-5 Stiffener Void Limits as a Percentage of Stiffener Surface Area 11
Table 3-6 Plating and Coating Voids Visual Examination 12
Table 3-7 Edge Board Contact Gap 12
Table 3-8 Minimum Etch Annular Ring 13
Table 3-9 Allowable Squeeze-Out of Coverlay Adhesive and Ooze-Out of Covercoat 14
Table 3-10 Minimum Solderable Annular Ring on Land Area 15
Table 3-11 Conductor Spacing Requirements 16
Table 3-12 Plated-Through Hole Integrity After Stress 19
Table 3-13 Internal Layer Foil Thickness after Processing 25
Table 3-14 External Conductor Thickness after Plating 25
Table 3-15 Solder Mask Adhesion 27
Table 3-16 Dielectric Withstanding Test Voltages 28
Table 3-17 Insulation Resistance 28
Table 4-1 Qualification Testing 31
Table 4-2 C=0 Sampling Plan for Equipment Classes per Lot Size 34
Table 4-3 Acceptance Testing and Frequency 34
Table 4-4 Quality Conformance Testing 38

Qualification and Performance Specification for Flexible Printed Boards

1 SCOPE

1.1 Statement of Scope This specification covers qualification and performance requirements of flexible printed boards (PBs). The flexible PB may be single-sided, double-sided, multilayer, or rigid-flex multilayer. All of these constructions may or may not include stiffeners, plated-through holes (PTHs), and blind/buried vias.

The flexible or rigid-flex PB may contain build up high density interconnect (HDI) layers conforming to IPC-6016. The PB may contain active embedded passive circuitry with distributive capacitive planes, capacitive or resistive components.

The rigid section of the PB may contain a metal core or external metal heat frame, which may be active or nonactive.

Revision level changes are described in 1.7.

1.2 Purpose The purpose of this specification is to provide requirements for qualification and performance of flexible PBs designed to IPC-2221 and IPC-2223.

1.3 Performance Classification, PB Type, and Installation Usage

1.3.1 Classification This specification recognizes that flexible PBs will be subject to variations in performance requirements based on end-use. These performance classes (Class 1, Class 2, and Class 3) are defined in IPC-6011.

1.3.2 PB Type Performance requirements are established for the different types of flexible PBs, classified as follows:

Type 1 Single-sided flexible PBs containing one conductive layer, with or without stiffeners.

Type 2 Double-sided flexible PBs containing two conductive layers with PTHs, with or without stiffeners.

Type 3 Multilayer flexible PBs containing three or more conductive layers with PTHs, with or without stiffeners.

Type 4 Multilayer rigid and flexible material combinations containing three or more conductive layers with PTHs.

Type 5 Flexible or rigid-flex PBs containing two or more conductive layers without PTHs.

1.3.3 Installation Uses

Use A Capable of withstanding flex during installation.

Use B Capable of withstanding continuous flexing for the number of cycles as specified in the procurement documentation.

Use C High temperature environment (over 105 °C [221 °F]).

Use D UL Recognition.

1.3.4 Selection for Procurement For procurement purposes, performance class and installation usage **shall** be specified in the procurement documentation.

The documentation **shall** provide sufficient information to the supplier so that the supplier can fabricate the flexible PBs and ensure that the user receives the desired product. Information that should be included in the procurement documentation is shown in IPC-D-325.

Note: If the drawing specifies the requirement in words, designators are not required.

1.3.4.1 Selection (Default) The procurement documentation should specify the requirements that can be selected within this specification. However, in the event that these selections are not made in the documentation, Table 1-1 **shall** apply:

1.3.5 Material, Plating Process and Final Finish

1.3.5.1 Laminate Material Laminate material is identified by numbers and/or letters, classes and types as specified by the appropriate specification listed in the procurement documentation.

1.3.5.2 Plating Process The copper plating process used to provide the main conductor in the holes is identified by a single number as follows:

1. Acid copper electroplating only
2. Pyrophosphate copper electroplating only
3. Acid and/or pyrophosphate copper electroplating
4. Additive/electroless copper
5. Electrodeposited Nickel underplate with copper electroplating

Note: Pyrophosphate copper electroplating is no longer in use.

1.3.5.3 Final Finish The final finish can be but is not limited to one of the designators given below or a combination of several platings and is dependent on assembly