IPC J-STD-003B

Solderability Tests for Printed Boards

Developed by the Printed Wiring Board Solderability Specification Task Group (5-23a) of the Assembly & Joining Processes Committee (5-20) of IPC

Supersedes:
J-STD-003A - February 2003
J-STD-003 - April 1992
IPC-S-804A - January 1987
IPC-S-803
IPC-S-801

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

Contact:
IPC
3000 Lakeside Drive, Suite 309S
Bannockburn, IL 60015-1249
Phone (847) 615-7100
Fax (847) 615-7105

Table of Contents

1 GENERAL ... 1
1.1 Scope ... 1
1.2 Purpose ... 1
1.3 Objective ... 1
1.3.1 Shall or Should ... 1
1.3.2 Document Hierarchy ... 1
1.4 Performance Classes ... 1
1.5 Method Classification ... 1
1.5.1 Visual Acceptance Criteria Tests ... 1
1.5.2 Force Measurement Criteria Tests ... 2
1.5.3 Test(s) Methodologies Under Committee Review ... 2
1.6 Test Method Selection ... 2
1.7 Test Specimen Requirements ... 2
1.8 Coating Durability ... 3
1.9 Limitation ... 3

2 APPLICABLE DOCUMENTS ... 3
2.1 Industry ... 3
2.1.1 IPC ... 3

3 REQUIREMENTS ... 3
3.1 Terms and Definitions ... 3
3.2 Materials ... 3
3.2.1 Solder ... 3
3.2.2 Flux ... 4
3.2.2.1 Flux Maintenance ... 4
3.2.3 Flux Removal ... 4
3.3 Equipment ... 4
3.3.1 Conditioning Equipment ... 4
3.3.2 Solder Pot/Bath ... 4
3.3.3 Optical Inspection Equipment ... 4
3.3.4 Dipping Equipment ... 4
3.3.5 Timing Equipment ... 4
3.4 Preparation for Testing ... 4
3.4.1 Test Specimen Preparation and Conditioning for Test ... 4
3.4.2 Durability Conditioning ... 4
3.4.3 Baking ... 4
3.5 Solder Bath Requirements ... 5
3.5.1 Solder Temperatures ... 5
3.5.2 Solder Contamination Control ... 5

4 TEST PROCEDURES ... 6
4.1 Test Procedure Limitations ... 6
4.1.1 Application of Flux ... 6
4.2 Tests with Established Accept/ Reject Criteria ... 7
4.2.1 Test A – Edge Dip Test Tin/Lead Solder ... 7
4.2.1.1 Apparatus ... 7
4.2.1.1.1 Solder Pot/Bath ... 7
4.2.1.1.2 Dipping Device ... 7
4.2.1.2 Test Specimen ... 7
4.2.1.3 Procedure ... 7
4.2.1.4 Evaluation ... 9
4.2.1.4.1 Magnification ... 9
4.2.1.4.2 Surface Evaluation – Accept/ Reject Criteria ... 9
4.2.2 Test B – Rotary Dip Test Tin/Lead Solder ... 9
4.2.2.1 Apparatus ... 9
4.2.2.2 Test Specimen ... 9
4.2.2.3 Procedure ... 9
4.2.2.4 Evaluation ... 9
4.2.2.4.1 Magnification ... 9
4.2.2.4.2 Surface Evaluation – Accept/ Reject Criteria ... 10
4.2.2.4.3 Plated-Through Hole Evaluation ... 10
4.2.3 Test C – Solder Float Test Tin/ Lead Solder ... 11
4.2.3.1 Apparatus ... 11
4.2.3.1.1 Solder Pot ... 11
4.2.3.1.2 Test Specimen Handling Tool ... 11
4.2.3.2 Test Specimen ... 11
4.2.3.3 Procedure ... 11
4.2.3.4 Evaluation ... 11
4.2.3.4.1 Magnification ... 11
4.2.3.4.2 Surface Evaluation – Accept/ Reject Criteria ... 11
4.2.3.4.3 Plated-Through Hole Evaluation ... 11
4.2.4 Test D – Wave Solder Test Tin/ Lead Solder ... 11
4.2.4.1 Apparatus ... 11
4.2.4.2 Test Specimen ... 11
4.2.4.3 Procedure ... 11
4.2.4.4 Evaluation ... 12
4.2.4.4.1 Magnification ... 12
4.2.4.4.2 Surface Evaluation – Accept/ Reject Criteria ... 12
4.2.4.4.3 Plated-Through Hole Evaluation ... 12

4.2.5 Test E – Surface Mount Process Simulation Test Tin/Lead Solder 12
4.2.5.1 Apparatus 12
4.2.5.1.1 Stencil/Screen 12
4.2.5.1.2 Paste Application Tool 12
4.2.5.2 Test Specimen 12
4.2.5.3 Reflow Equipment 12
4.2.5.4 Procedure 13
4.2.5.5 Evaluation 13
4.2.5.5.1 Magnification 13
4.2.5.5.2 Surface Evaluation – Accept/ Reject Criteria 13
4.2.6 Test A1 – Edge Dip Test Lead-Free Solder 14
4.2.6.1 Apparatus 14
4.2.6.1.1 Solder Pot/Bath 14
4.2.6.1.2 Dipping Device 14
4.2.6.2 Test Specimen 14
4.2.6.3 Procedure 14
4.2.6.4 Evaluation 14
4.2.6.4.1 Magnification 14
4.2.6.4.2 Surface Evaluation – Accept/ Reject Criteria 14
4.2.7 Test B1 – Rotary Dip Test Lead-Free Solder 14
4.2.7.1 Apparatus 14
4.2.7.2 Test Specimen 14
4.2.7.3 Procedure 14
4.2.7.4 Evaluation 15
4.2.7.4.1 Magnification 15
4.2.7.4.2 Surface Evaluation – Accept/ Reject Criteria 15
4.2.7.4.3 Plated-Through Hole Evaluation 15
4.2.8 Test C1 – Solder Float Test Lead-Free Solder 15
4.2.8.1 Apparatus 15
4.2.8.1.1 Solder Pot 15
4.2.8.1.2 Test Specimen Handling Tool 15
4.2.8.2 Test Specimen 15
4.2.8.3 Procedure 15
4.2.8.4 Evaluation 15
4.2.8.4.1 Magnification 15
4.2.8.4.2 Surface Evaluation – Accept/ Reject Criteria 15
4.2.8.4.3 Plated-Through Hole Evaluation 16
4.2.9 Test D1 – Wave Solder Test Lead-Free Solder 16
4.2.9.1 Apparatus 16
4.2.9.2 Test Specimen 16
4.2.9.3 Procedure 16
4.2.9.4 Evaluation 16
4.2.9.4.1 Magnification 16
4.2.9.4.2 Surface Evaluation – Accept/ Reject Criteria 16
4.2.9.4.3 Plated-Through Hole Evaluation 16
4.2.10 Test E1 – Surface Mount Process Simulation Test Lead-Free Solder 16
4.2.10.1 Apparatus 17
4.2.10.1.1 Stencil/Screen 17
4.2.10.1.2 Paste Application Tool 17
4.2.10.2 Test Specimen 17
4.2.10.3 Reflow Equipment 17
4.2.10.4 Procedure 17
4.2.10.5 Evaluation 17
4.2.10.5.1 Magnification 17
4.2.10.5.2 Surface Evaluation – Accept/ Reject Criteria 17
4.3 Tests with Force Measurement Criteria 18
4.3.1 Test F – Wetting Balance Test: Tin/Lead Solder 18
4.3.1.1 Apparatus 18
4.3.1.1.1 Dipping Device 18
4.3.1.2 Test Specimen 18
4.3.1.3 Procedure 18
4.3.1.4 Evaluation 19
4.3.1.4.1 Magnification 19
4.3.1.4.2 Suggested Criteria 19
4.3.1.5 Gauge Repeatability and Reproducibility (GR&R) Protocol 19
4.3.2 Test F1 – Wetting Balance Test: Lead-Free Solder 21
4.3.2.1 Apparatus 21
4.3.2.1.1 Dipping Device 21
4.3.2.2 Test Specimen 21
4.3.2.3 Procedure 21
4.3.2.4 Evaluation 21
4.3.2.4.1 Magnification 21
4.3.2.4.2 Suggested Criteria 21
4.3.2.5 Gauge Repeatability and Reproducibility (GR&R) Protocol 21

5 EVALUATION AIDS 22
5.1 Evaluation Aids – Surface 22
5.2 Evaluation Aids – For Class 3 Plated-Through Holes 22

6 NOTES 23

6.1 Correction for Buoyancy 23
6.2 Preheat 23
6.3 Baking 23
6.4 Prebaking 23
6.5 Safety Note 23
6.6 Use of Nonactivated Flux 23
6.7 Solder Contact 23

APPENDIX A Calculation of Maximum Theoretical Force for a Rectangular Cross-Section 24

APPENDIX B Calculation of Area Under the Wetting Curve 25

APPENDIX C Informative Annex 26

APPENDIX D Test Protocol for Wetting Balance Gauge Repeatability and Reproducibility (GR&R) Using Copper Foil Coupons 27

APPENDIX E J-STD-002/J-STD-003 Activated Solderability Test Flux Rationale Committee Letter 28

Figures

Figure 3-1 Contact Angle 3
Figure 3-2 Example Reticle 5
Figure 4-1 Edge Dip Solderability Test 7
Figure 4-2 Suggested Test Specimen for Plated-Through Holes 8
Figure 4-3 Suggested Test Specimen for Surface Mount Features 8
Figure 4-4 Rotary Dip Test 9
Figure 4-5 Effectiveness of Solder Wetting of Plated-Through Holes - Class 3 10
Figure 4-6 Examples of Solder Wetting of Plated-Through Holes - Class 3 10
Figure 4-7 Wetting Balance Apparatus 18
Figure 4-8 Suggested Wetting Balance Test Specimens and Soldering Immersion 18
Figure 4-9 Wetting Balance Test Soldering Immersion ... 19
Figure 4-10 Set A Wetting Curve 20
Figure 4-11 Set B Wetting Curve 20
Figure 5-1 Aid to Evaluation 22

Tables

Table 1-1 Test Method Selection 2
Table 1-2 Conditioning and Test Requirements 3
Table 3-1 Flux Composition 4
Table 3-2 Maximum Limits of Solder Bath Contaminant 5
Table 4-1 Stencil Thickness Requirements 12
Table 4-2 Reflow Parameter Requirements 12
Table 4-3 Stencil Thickness Requirements 17
Table 4-4 Lead-Free Reflow Parameter Requirements 17
Table 4-5 Wetting Balance Parameter and Suggested Criteria 19
Table 4-6 Wetting Balance Parameter and Suggested Criteria 21

Solderability Tests for Printed Boards

1 GENERAL

1.1 Scope This standard prescribes test methods, defect definitions and illustrations for assessing the solderability of printed board surface conductors, attachment lands, and plated-through holes. This standard is intended for use by both vendor and user.

1.2 Purpose The solderability determination is made to verify that the printed board fabrication processes and subsequent storage have had no adverse effect on the solderability of those portions of the printed board intended to be soldered. This is determined by evaluation of the solderability test specimen portion of a board or representative test specimen which has been processed as part of the panel of boards and subsequently removed for testing per the method selected.

1.3 Objective The objective of the solderability test methods described in this standard is to determine the ability of printed board surface conductors, attachment lands, and plated-through holes to wet easily with solder and to withstand the rigors of the printed board assembly processes.

1.3.1 Shall or Should The word ''**shall**'' is used in the text of this document wherever there is a requirement for materials, preparation, process control or acceptance of a soldered connection or a test method. The word ''should'' reflects recommendations and is used to reflect general industry practices and procedures for guidance only.

1.3.2 Document Hierarchy In the event of conflict, the following descending order of precedence applies:

1. Procurement as agreed between user and supplier.
2. Master drawing or master assembly drawing reflecting the user's detailed requirements.
3. When invoked by the customer or per contractual agreement, this document, J-STD-003.
4. Other documents to extent specified by the customer.

1.4 Performance Classes Three general classes have been established to reflect progressive increases in sophistication, functional performance requirements and testing/inspection frequency. It should be recognized that there may be an overlap of equipment categories in different classes. The user has the responsibility to specify in the contract or purchase order the performance class required for each product and **shall** indicate any exceptions to specific parameters, where appropriate.

Class 1 – General Electronic Products

Includes consumer products, some computer and computer peripherals suitable for applications where cosmetic imperfections are not important and the major requirement is function of the completed printed board.

Class 2 – Dedicated Service Electronic Products

Includes communications equipment, sophisticated business machines, instruments where high performance and extended life is required and for which uninterrupted service is desired but not critical. Certain cosmetic imperfections are allowed.

Class 3 – High Performance Electronic Products

Includes the equipment and products where continued performance or performance on demand is critical. Equipment downtime cannot be tolerated and must function when required such as in life support items or flight control systems. Printed boards in this class are suitable for applications where high levels of assurance are required and service is essential.

1.5 Method Classification This standard describes test methods by which both the surface conductors (and attachment lands) and plated-through holes may be evaluated for solderability. Test A, Test B, Test C, Test D and Test E for tin/lead solder processes and Test A1, Test B1, Test C1, Test D1 and Test E1 for lead-free solder processes, unless otherwise agreed upon between vendor and user. Test A and Test C for tin/lead solder processes, Test A1 and Test C1 for lead-free solder processes are to be used as a default solderability tests.

Provisions are made for this determination to be performed at the time of manufacture, at the receipt of the boards by the user, or just prior to assembly and soldering. User and vendor **shall** agree to the appropriate method to be used and their correlation.

Standard dwell times are defined in some of the methods called out in this standard. Variations in board heat capacity may necessitate the use of longer solder dwell times (see 6.2). Any change in solder dwell **shall** be agreed upon by user and vendor.

1.5.1 Visual Acceptance Criteria Tests

Tin Lead Solder Alloy

Test A – Edge Dip Test For surface conductors and attachment lands only (see 4.2.1)
Test B – Rotary Dip Test For plated-through holes, surface conductors and attachment lands, solder source side (see 4.2.2)