Troubleshooting for Printed Board Assembly Processes

Developed by Assembly Process Effects Handbook Subcommittee (7-23) of the Process Control Management Committee (7-20) of IPC

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

Contact:

IPC
Table of Contents

1 GENERAL INTRODUCTION ............................................. 1-1
1.1 Purpose and Format .................................................. 1-1
1.2 Guidelines for Effective Troubleshooting and Process Control ............................................. 1-2
1.3 Parameter Analysis ..................................................... 1-3
1.3.1 Brainstorming .......................................................... 1-3
1.3.2 Process Audit ............................................................ 1-3
1.3.3 Initial Capability Study ........................................... 1-3
1.3.4 Optimization ............................................................ 1-3
1.3.5 Confirmation and Final Capability Assessment .......................................................... 1-3
1.3.6 Parameter Control ..................................................... 1-4
1.3.7 Corrective Action Plan ............................................... 1-4
1.4 Applicable Documents .................................................. 1-4
1.4.1 IPC ........................................................................... 1-4

2 DESIGN AND DOCUMENTATION ............................................. 2-1
2.1 Component Positioning ................................................... 2-1
  Issue: SMT chip components twist off lands during reflow .................................................. 2-1
  Issue: Insufficient toe and heel fillets .............. 2-1
  Issue: Through hole components do not consistently go into mounting holes during automatic assembly ............................................. 2-2
  Issue: Cannot access component for repair .......................................................... 2-2
  Issue: Delicate component bodies crack during the thermal cycles of assembly ............. 2-2
  Issue: Small components exhibit poor solder joint formation ....................................... 2-2
  Issue: Unable to maximize manufacturing capability, or optimize construction and assembly choices to obtain best solutions for end product functionality and performance ............................................. 2-2
  Issue: Unable to determine acceptance criteria .......................................................... 2-2

3 TOOLING AND FIXTURING ................................................... 3-1
3.1 Terminals ................................................................. 3-1
  Issue: Terminals and eyelets, swaged base split .................................................. 3-1

4 HANDLING AND STORAGE ................................................... 4-1
4.1 Component Mounting Solderability and Contamination .................................................. 4-1
  Issue: Leads do not accept solder .............. 4-1
  Issue: Leads do not float ............................................. 4-1
  Board Preparation .......................................................... 4-2
  Issue: Residue at incoming inspection. Incoming residue may be associated with either the manufacture of the boards and components, or their handling and storage ............................................. 4-2
  Issue: Paste is dry ......................................................... 4-2
  Issue: PWB warps or delaminates after reflow .......................................................... 4-2
  Issue: Poor SOT 23 Component Compatibility .......................................................... 4-3
  Issue: QFP Cracking Popcorning ............................................. 4-3
5 ASSEMBLY MATERIAL ............................................. 5-1
   Issue: Flux on top of paste ......................... 5-1
   Issue: Crust on top of paste ....................... 5-1
   Issue: Dry solder paste ......................... 5-2
   Issue: Conformal Coating bubbles ............ 5-2

6 MECHANICAL OPERATION ...................................... 6-1

6.1 Stencil Printing: Insufficient solder paste .... 6-1
   Issue: Insufficient solder paste deposited to form a reliable solder joint .................. 6-1
   Issue: Insufficient solder paste deposited to form a reliable solder joint while the rest of the circuit board is printed cleanly. A number of factors can contribute to this. ..................... 6-2
   Issue: Inconsistent print when the squeegee travels in opposite directions .......... 6-3
   Issue: Insufficient paste ......................... 6-3
   Issue: Skip Un-Soldered Surface Mount Termination ........................................ 6-4

6.2 Stencil Printing: Excessive Solder Paste ........ 6-4
   Issue: Excess solder paste deposited. Excess solder after reflow or solder shorts caused by excess solder paste deposits and wet bridging .................................................. 6-4
   Issue: Excessive Paste ............................ 6-5
   Issue: Paste Smear .................................... 6-6

6.3 Stencil Printing: General Observations ........ 6-6
   Issue: Uneven marks on stencil ................ 6-6
   Issue: Paste misalignment ........................ 6-6
   Issue: Paste fringing on stencil after printing .................................................. 6-7
   Issue: Thin streaks of paste across stencil .... 6-7
   Issue: Uneven print across board ................ 6-7
   Issue: Ridges around top of paste bricks .... 6-7
   Issue: Foreign material in paste on board ..... 6-8
   Issue: Excess flux on panel ....................... 6-8
   Issue: Paste covering land but metallization showing through .......................... 6-8
   Issue: Paste slump .................................. 6-8
   Issue: Misaligned print ........................... 6-9
   Issue: Paste misalignment during component printing ........................................ 6-9

6.4 Screen Printing ............................................. 6-10
   Issue: Insufficient solder paste deposited .... 6-10

6.5 Syringe Dispensing ........................................ 6-11
   Issue: Solder paste flow stops ..................... 6-11
   Issue: Dispenser has difficulty delivering consistent amounts with each shot (a sure sign is solder paste strings when the dispensing head moves from one pad to another) ........................................... 6-11
   Issue: Solder paste deposit not rounded enough .................................................. 6-11
   Issue: Solder paste deposit not peaked enough .................................................... 6-11
   Issue: Solder paste will not adhere to the pad ....................................................... 6-12
   Issue: Tooling pin error ............................ 6-12
   Issue: Panel stuck on conveyor .................... 6-12
   Other .................................................. 6-12
   Issue: Inconsistent solder paste deposition on surface mount assembly ................ 6-12

7 COMPONENT PREPARATION .................................... 7-1

7.1 Pre-tinning ............................................ 7-1
   Issue: Leads do not accept solder ................ 7-1
   Issue: Leads do not float .......................... 7-1

7.2 Pre-forming ............................................. 7-1
   Issue: Bent IC leads ............................... 7-1
   Issue: Improper lead bend ......................... 7-1
   Issue: Nicked leads .................................. 7-1
   Issue: Incorrect stress relief ....................... 7-1
   Issue: Cracked or Fractured Meniscus .......... 7-2

7.3 Pre-cutting ............................................. 7-2
   Issue: Uneven leads ................................ 7-2
   Issue: Burrs on leads .............................. 7-2
   Issue: Leads with flanged ends .................. 7-2
   Issue: Leads too long or too short .............. 7-2
   Lead Pre-Cutting ..................................... 7-2
   Issue: Uneven leads ................................ 7-2
   Issue: Burrs on leads .............................. 7-2
   Issue: Leads with flanged ends .................. 7-2
   Issue: Leads too long or too short .............. 7-3
8 COMPONENT MOUNTING SITE PREPARATION ...................................................... 8-1

8.1 Jetting solder paste ............................................ 8-1

**Issue:** Solder paste flow stops .......................... 8-1

**Issue:** Jet printer has difficulty delivering consistent amounts with each shot .............. 8-1

**Issue:** Solder not wetting land area .................. 8-1

**Issue:** Solder paste printing problems .......... 8-2

8.2 Syringe Dispensing ............................................ 8-2

**Issue:** Solder paste flow stops .......................... 8-2

**Issue:** Dispenser has difficulty delivering consistent amounts with each shot (a sure sign is solder paste strings when the dispensing head moves from one pad to another) .............. 8-2

**Issue:** Solder paste deposit not rounded enough .................................................. 8-2

**Issue:** Solder paste deposit not peaked enough .................................................. 8-2

**Issue:** Solder paste will not adhere to the pad .................................................. 8-3

8.3 Adhesive Application Dispensing ..................... 8-3

**Issue:** Stringing (most frequently related to both dispenser and adhesive) .............. 8-3

**Issue:** Nozzle clogging (most frequently related to down time, curing, and foreign matter) .................................................. 8-3

8.4 Pin Dip Transfer ................................................ 8-3

**Issue:** Skipping and insufficient adhesive (most frequently related to clogged nozzle) .... 8-3

**Issue:** Excessive adhesive (most frequently related to thixotropic properties of adhesive, temperature of reservoir, and equipment controls) .................................................. 8-4

**Issue:** Insufficient cure (most frequently related to insufficient curing energy leaving soft, gummy, or tacky adhesive) .............. 8-4

8.5 Dispensing ...................................................... 8-5

**Issue:** Stringing (most frequently related to withdrawal rate and viscosity) .............. 8-5

**Issue:** Skipping and insufficient adhesive (most frequently related to amount of adhesive on pins) .................................................. 8-5

**Issue:** Excessive adhesive (most frequently related to flow properties of adhesive and variations in temperature of the reservoir) .... 8-5

8.6 Adhesive Application ........................................ 8-6

8.6.1 Dispensing ...................................................... 8-6

**Issue:** Stringing (most frequently related to both dispenser and adhesive) .............. 8-6

**Issue:** Nozzle clogging (most frequently related to down time, curing, and foreign matter) .................................................. 8-6

**Issue:** Skipping and insufficient adhesive (most frequently related to clogged nozzle) .... 8-6

**Issue:** Excessive adhesive (most frequently related to thixotropic properties of adhesive, temperature of reservoir, and equipment controls) .................................................. 8-7

**Issue:** Insufficient cure (most frequently related to insufficient curing energy leaving soft, gummy, or tacky adhesive) .............. 8-7

**Issue:** Lost components (most frequently related to insufficient cure, poor bond or adhesive, or non-wetted component) .......... 8-7

**Issue:** Adhesive voids (most frequently related to the presence of moisture in adhesive or on surfaces) .................................................. 8-7

**Issue:** Tombstoning ............................................. 8-8
9 COMPONENT PLACEMENT ............................................. 9-1

9.1 Component Placement/Positioning ....................... 9-1

Issue: Inaccurate component placement
(all or many components on a board) ................. 9-1
Issue: Inaccurate component placement
(occasional component on board) ....................... 9-1
Issue: Inaccurate component placement
(one component type affected) ......................... 9-1
Issue: Feeder is not feeding parts correctly
(sensor will stop the machine) ......................... 9-1
Issue: Machine stops; component not
picked up ........................................................ 9-1

9.2 Component Insertion (Through-hole)
Manual/Semi-Automatic .................................... 9-2

Issue: Incorrect Laser placement marking .......... 9-2

9.3 Component Orientation/Alignment .................... 9-2

Issue: Wrong component orientation ............. 9-2
Issue: Cocking of passive chip components ... 9-2
Issue: Component Misalignment .................... 9-2

9.4 Machine Errors ................................................. 9-3

Issue: Missing component ......................... 9-3
Issue: Wrong component placed .................. 9-3

9.5 Component Condition After Placement .......... 9-4

Issue: Damaged component ......................... 9-4
Issue: Metallized termination of ceramic
component cracked or separated from
component body ............................................. 9-4
Issue: Cracked multilayer ceramic
component with crack(s) originating
under the metallized termination .................... 9-4
Issue: Cracked multilayer ceramic
component with crack(s) originating
between the metallized terminations ............ 9-4

9.6 Machine Errors ................................................. 9-5

Issue: Can’t read fiducial(s) ......................... 9-5
Issue: Mis-pick from tape feeder .................... 9-5
Issue: Panel stuck on conveyor ..................... 9-5

9.7 Automatic Insertion (Through-Hole) .................. 9-5

Issue: Mis-insertion .................................. 9-5
Issue: Reversed part .................................. 9-5
Issue: Part off-center .................................. 9-5
Issue: Damaged part .................................. 9-5
Issue: Mis-insertion .................................. 9-6
Issue: Over crimp .................................. 9-6
Issue: Under crimp .................................. 9-6
Issue: Leads too long or too short ................ 9-6

9.8 Manual/Semi-automatic through insertion ........ 9-6

Issue: Terminals and eyelets, swaged
base split .................................................. 9-6
Issue: Terminal and eyelets, mounts
are cracked ............................................... 9-6

9.9 Automatic Insertion (Through-Hole) .................. 9-6

Issue: Mis-insertion .................................. 9-6
Issue: Reversed Part .................................. 9-6
Issue: Part off-center ................................ 9-7
Issue: Damaged part .................................. 9-7
Issue: Mis-insertion .................................. 9-7
Issue: Over crimp .................................. 9-7
Issue: Under crimp .................................. 9-7
Issue: Leads too long or too short ................ 9-7
Issue: Inaccurate component placement
(all or many components on a board) ............ 9-7
Issue: Inaccurate component placement
(occasional component on board) ............... 9-7
Issue: Inaccurate component placement
(one component type affected) .................. 9-8
Issue: Feeder is not feeding parts correctly
(sensor will stop the machine) .................... 9-8
Issue: Machine stops; component not
picked up .................................................. 9-8
10 COMPONENT ATTACHMENT .......................... 10-1
10.1 Design ....................................................... 10-1
10.1.1 Design Related Problems ............................... 10-1
    Issue: Solder skips ........................................... 10-1
    Issue: Solder bridges ......................................... 10-1
    Issue: Unfilled via holes ..................................... 10-1
    Issue: Solder projections ..................................... 10-1
10.2 Materials .................................................. 10-2
10.2.1 Material/Prior Process Related Problems .......... 10-2
    Issue: Solder skips ........................................... 10-2
    Issue: Solder bridges ......................................... 10-2
    Issue: Unfilled via holes ..................................... 10-3
    Issue: Solder wave over-flooding board ................. 10-3
    Issue: Grainy or disturbed joints ......................... 10-3
    Issue: Cold joints ............................................ 10-3
    Issue: Solder balls on assembly ............................ 10-4
    Issue: Cracked chip components or plastic-bodied leaded components ......................... 10-4
    Issue: Solder projections ..................................... 10-4
    Issue: Lead does not accept solder ....................... 10-4

10.3 Reflow ...................................................... 10-4
10.3.1 Infrared/Convection Reflow Soldering ............. 10-4
    Issue: No reflow of paste or preforms .................... 10-4
    Issue: Dull, graying, crystallized solder ............... 10-4
    Issue: Opens (most frequently caused by lead coplanarity or solder wicking) ...................... 10-5
    Issue: Tombstoning (most frequently caused by unequal melt or solder paste quantity) ....... 10-5
    Issue: Solder balls (most frequently caused by outdated paste or insufficient preheat) ....... 10-5
    Issue: Component alignment (most frequently caused by pad design or placement error) ........... 10-5
    Issue: Capacitor cracking (most frequently caused by thermal shock or placement handling) ...................... 10-5
    Issue: Plastic package cracking (most frequently caused by water entrapped in plastic) .......... 10-5
    Issue: Low surface insulation resistance (most frequently caused by flux entrapped under component) .......................................................... 10-5
    Issue: Insufficient solder fillets (most frequently caused by insufficient solder paste) .............. 10-6
    Issue: Non-soldering (electrical open) ................... 10-6

10.3.2 Equipment/Process-Related Problems ............... 10-6
    Issue: No reflow of paste or preforms .................... 10-6
    Issue: Dull, graying, crystallized solder ............... 10-6
    Issue: Opens .................................................. 10-6
    Issue: Tombstoning .......................................... 10-7
    Issue: Bridges (most frequently caused by solder application registration tolerance) ........ 10-7
    Issue: Solder Balls ........................................... 10-7
    Issue: Component alignment ................................ 10-7
    Issue: Capacitor cracking ................................ 10-7
    Issue: Plastic package cracking ............................ 10-8
    Issue: Low surface insulation resistance ................ 10-8
    Issue: Insufficient solder fillets ......................... 10-8
    Issue: Non-soldering (electrical open) ................... 10-8

10.3.3 Material/Prior-Process Related Problems .......... 10-9
    Issue: No reflow of solder paste/cold solder joints, nonwetting ........................................... 10-9
    Issue: No solders: Dewetting ................................ 10-9
    Issue: Uneven reflow .......................................... 10-9
    Issue: Solder balls (often due to excessive outgassing of the paste or boards during reflow, or an excess of oxide on the paste particles, components, or boards) ................. 10-9
    Issue: Charring of board/components (thermal damage to the boards or components during reflow can be due to oven temperature or uneven thermal transfer during reflow) .................................................. 10-10
    Issue: Damaged components ................................ 10-10
    Issue: Cracked joints (physical damage to the solder joints can occur if the assemblies are moved while the solder joints are still liquid, or if the assemblies are handled in such a way as to damage the cooled solder joints) .................................................. 10-10
    Issue: Voids (result of entrapment of flux or other volatiles in the solder joints during reflow) .................................................. 10-10
    Issue: Opens .................................................. 10-10
    Issue: Spatter (related to solder balling) ............... 10-10
    Issue: Tombstoning (the raising up of one end of a chip component during reflow) ................ 10-11

10.3.4 Equipment/Process-Related Problems ............... 10-11
    Issue: No reflow of solder paste/cold solder joints .................................................. 10-11
    Issue: No solder (solder not present) .................... 10-11
    Issue: Nonwetting ............................................. 10-11
    Issue: Dewetting .............................................. 10-12
    Issue: Uneven reflow .......................................... 10-12
Issue: Solder balls ................................. 10-12
Issue: Charring of board/components .......... 10-12
Issue: Cracked joints ............................. 10-12
Issue: Insufficient solder .......................... 10-12
Issue: Bridging ....................................... 10-13
Issue: Voids ........................................... 10-13
Issue: Opens, electrical ......................... 10-13
Issue: Splatter ........................................ 10-13
Issue: Tombstoning ............................... 10-13
Issue: Excessive solder after reflow .......... 10-14
Issue: Insufficient solder after reflow ........ 10-14
Issue: Missing solder ............................. 10-15
Issue: Component Misalignment/ Tombstoning ................................. 10-15
Issue: Solder balls .................................. 10-16
Issue: Solder Bridging After Reflow ........... 10-16
Issue: BGA Open Solder Joint – Head In Pillow ........................................ 10-17
Issue: Poor Wetting or Non-Wetting ............ 10-18
Issue: Dewetting ..................................... 10-18
Issue: Incomplete Reflow ......................... 10-19
Issue: Inconsistent Paste In Hole Reflowed Joints ........................................ 10-19
Issue: Solder Beading/Mid-Chip Solder Balls ........................................ 10-20

10.4 Wave Soldering .................................. 10-20
Issue: Cold solder joints on power or ground connections for through hole components ... 10-20
Issue: Reflow soldered surface mount lands with via connections demonstrate solder depletion after wave solder ........................ 10-20
Issue: Inconsistent solder volume when wave soldering surface mount components .. 10-20

10.4.1 Equipment Related Problems .................. 10-21
Issue: Solder skips .................................. 10-21
Issue: Solder bridges .............................. 10-21
Issue: Unfilled via holes .......................... 10-21
Issue: Solder wave-over-flooding board ....... 10-22
Issue: Grainy or disturbed joints ............... 10-22
Issue: Cold joints .................................... 10-22
Issue: Solder balls on assembly .................. 10-22
Issue: Cracked chip components or plastic-bodied leaded components .................. 10-22
Issue: Solder projections components- ........ 10-23
Issue: Excessive or insufficient solder .......... 10-23
Issue: Overheated solder connection .......... 10-23

Issue: Lead-Free Through Hole Copper Erosion ........................................ 10-23
Issue: Component not removable after solder reflow or lifted lands upon attempted removal ........................................ 10-24
Issue: Lands being lifted or damaged during removal of old solder .................. 10-24
Issue: Insufficient solder reflow to effect component removal .......................... 10-24
Issue: Insufficient or poor adhesion of solder on lands during pretinning operation ........................................ 10-24
Issue: Dispersion or solder balling of solder paste during reflow .................. 10-25
Issue: Lead-Free Through Hole Copper Erosion ........................................ 10-25

10.7 Soldering: General Issues ......................... 10-25
10.7.1 Soldering General Problems ................... 10-25
Issue: Lead does not solder ....................... 10-25
Issue: Defective solder joints ..................... 10-25
Issue: Rosin solder connection ................... 10-25
Issue: Nonwetting/dewetting ..................... 10-26
Issue: Insufficient solder reflow to effect SMD removal ........................................ 10-26
Issue: Misalignment of component to land pattern during SMD installation ........ 10-26
Issue: Dispersion or solder balling of solder paste during reflow .................. 10-26
Issue: Blistering or measling of substrate, or lifted lands during installation or removal ... 10-26

10.8 Heat Transfer ...................................... 10-26
10.8.1 Convective Heating Methods .................. 10-26
Issue: Insufficient solder reflow to effect removal ........................................ 10-26
Issue: Misalignment of component to land pattern during SMD installation ........ 10-26
Issue: Dispersion or solder balling of solder paste during reflow .................. 10-27
Issue: Blistering or measling of substrate, or lifted lands during installation or removal ... 10-27
Issue: PCB Edge Delamination ..................... 10-27
11 CLEANING .............................................................. 11-1
11.1 Inspection and Test Cleanliness Ionic Contamination ......................... 11-1
   Issue: Results indicate excessive contamination or wide variations in readings among test parts within the same lot ................................................. 11-1
   Issue: Machine keeps running and does not reach an endpoint, and/or readings are inconsistent ................................................................. 11-1
11.2 Cleaning Solder Flux Removal ........................................... 11-2
   Issue: Flux residue (aqueous) ............................................. 11-2
   Issue: Flux residue (solvent) .................................................. 11-3
   Issue: White residue (aqueous) .............................................. 11-3
   Issue: White residue (solvent) ................................................. 11-4
   Issue: High solvent extract resistivity (aqueous) ................................ 11-4
   Issue: High solvent extract resistivity (solvent) ................................ 11-4
   Issue: Component/PWB degradation (aqueous) ................................ 11-5
   Issue: Component/PWB degradation (solvent) .................................. 11-5
   Issue: Excessive cleaner loss (aqueous) ...................................... 11-5
   Issue: Excessive cleaner loss (solvent) ....................................... 11-6
   Issue: Detergent foaming (aqueous) .......................................... 11-6
11.3 Legend Ink Removal .......................................................... 11-6
   Issue: Inadequate removal (aqueous) ......................................... 11-6
   Issue: Inadequate removal (solvent) ........................................... 11-6
12 COATING AND MARKING ................................................... 12-1
12.1 General Overview ............................................................ 12-1
12.2 Problems with Coating Storage ............................................. 12-1
   Issue: Skinning over in the can .................................................. 12-1
12.3 Problems with Base Material Preparation ..................................... 12-1
   Issue: .................................................................................. 12-1
12.4 Problems Due to Coating Application Methods .................................. 12-1
   12.4.1 Effects on Components .................................................... 12-1
      Issue: Component loses marking ................................ 12-1
      Issue: Cob webbing .......................................................... 12-2
   12.4.2 Defects – Bubbles ......................................................... 12-2
      Issue: .............................................................. 12-2
   12.4.3 Defects – Dewetting ....................................................... 12-3
      Issue: Dewetting during coating application ......................... 12-3
   12.4.4 Defects – Variations In Uniformity .................................... 12-3
      Issue: Inconsistent coating thickness ................................. 12-3
   12.4.5 Coating outside designed area ......................................... 12-4
      Issue: Coating penetration under mask .................................. 12-4
   12.5 Problems due to Coating Curing Methods ..... 12-4
      Issue: Incomplete cure ...................................................... 12-4
   12.6 Problems Due to Environmental Stress Testing ......................... 12-5
      Issue: Coating Cracking .................................................... 12-5
      Issue: Mealing ............................................................ 12-5
      Issue: Milky appearance of coating film ............................ 12-5
   12.7 Problems Specific To Coating Types ..................................... 12-6
      12.7.1 Polyurethane Coatings ............................................... 12-6
         Issue: Coating has runs or sags ........................................ 12-6
         Issue: Coating does not wet some areas of some components on the PWB assembly ................................................. 12-6
         Issue: “Fish eyes” in coating ........................................... 12-6
         Issue: Bubbles in coating .............................................. 12-6
         Issue: Poor adhesion ..................................................... 12-6
      12.7.2 Silicone Conformal Coatings ........................................ 12-7
         Issue: Coating takes excessive amount of time to fully cure ........ 12-7
         Issue: Silicone coated PWB assembly attracts foreign particles which cannot be removed by normal cleaning process .............. 12-7
      12.7.3 Paraxylylene Conformal Coatings .................................. 12-7
         Issue: Coating is on areas which do not require coating ........... 12-7
         Issue: Coating exhibits poor adhesion to PWB assembly which had been previously coated with paraxylylene .................................... 12-7
         Issue: Coating chamber does not seal adequately .................. 12-7
13 INSPECTION ........................................................ 13-1
13.1 Inspection ......................................................... 13-1
   Issue: Unable to perform inspections .......... 13-1

14 TESTING .............................................................. 14-1
14.1 Electrical Continuity ................................. 14-1
   Issue: Test shows failures that cannot be verified .......... 14-1
   Issue: Opens on surface that cannot be verified .......... 14-1
   Issue: Shorts on surface .......................... 14-2
   Issue: Unable to perform and complete testing of printed boards ........... 14-2
   Issue: Test opens on boards that are verifiable .......... 14-2
14.2 Test .............................................................. 14-3
   Issue: Unable to perform tests .......... 14-3
   Issue: BGA Pad Cratering .......................... 14-3

15 RELIABILITY STRESS CONDITIONING ....... 15-1
15.1 Reliability ....................................................... 15-1
   Issue: Installed printed board assembly experiences intermit tent failures; returns to operational condition after being removed and reinstalled ........................................ 15-1
   Issue: Installed printed board assembly fails in operational environment where equipment experiences shock and vibration ................... 15-1
   Issue: Solder joint cracked ....................... 15-1
   Issue: Ceramic capacitor crack ............... 15-2
   Issue: Corrosion under Conformal Coating .................................................. 15-2
   Issue: Crack after thermocycling .............. 15-3
   Issue: Solder Joint Crack on Flexible Circuit .................................................. 15-3
   Issue: Solder Joint Failure SOT23 .......... 15-4
   Issue: Tin Whiskers ............................... 15-4
Troubleshooting for Printed Board Assembly Processes
Section 1 - General Introduction

1 GENERAL INTRODUCTION
The Process Effects Committee of the IPC has developed this Process Control Handbooks for Printed Board Manufacture and Assembly, which is a documentation of problems, process causes, and the possible corrective action that may be taken. The inputs were voluntarily established by technical representatives of IPC member companies and have been reviewed in open discussion at the Process Effects Handbook meetings prior to publication.

New inputs are encouraged to help assure that the future Process Control Handbooks are complete and match the latest state-of-the-art in a particular subject.

1.1 Purpose and Format
The purpose of this Handbook is to provide guidance in the form of troubleshooting examples, process cause and effect information and statistical methods for correcting problems in all areas relating to the design, manufacture, assembly, and test of printed wiring products. A comprehensive Table of Contents deals with all of the various aspects of the design through delivery cycle.

The Guideline has been segmented into 16 major sections:

<table>
<thead>
<tr>
<th>Section</th>
<th>Topic Descriptions</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General information</td>
<td>Terminology</td>
</tr>
<tr>
<td>2</td>
<td>Documentation</td>
<td>Assembly drawing, Bill of Materials (BOM), Specification Control details, work instructions, routers, Specifications</td>
</tr>
<tr>
<td>3</td>
<td>Tooling and Fixturing</td>
<td>Stencils, Holding devices, Calipers, Torque devices</td>
</tr>
<tr>
<td>4</td>
<td>Handling and Storage</td>
<td>Materials, PWBs, and components</td>
</tr>
<tr>
<td>5</td>
<td>Assembly Material</td>
<td>Solder, flux, paste, adhesive, encapsulation</td>
</tr>
<tr>
<td>6</td>
<td>Mechanical Operation</td>
<td>Stenciling, paste deposition, converyorization</td>
</tr>
<tr>
<td>7</td>
<td>Component Preparation</td>
<td>Lead forming and trimming, verification, and kitting</td>
</tr>
<tr>
<td>8</td>
<td>Component Mounting Site Preparation</td>
<td>Land pattern redressing, solder dotting, adhesive application, solder jetting</td>
</tr>
<tr>
<td>9</td>
<td>Component Placement</td>
<td>Insertion, SMT, bare die</td>
</tr>
<tr>
<td>10</td>
<td>Component Attachment</td>
<td>Reflow, wave solder, fountain soldering, hand soldering, welding, surface contact, press fit</td>
</tr>
<tr>
<td>11</td>
<td>Cleaning</td>
<td>Manual and automated; in-process and final</td>
</tr>
<tr>
<td>12</td>
<td>Coating and Marking</td>
<td>Conformal coating, assembly serialization, and labels</td>
</tr>
<tr>
<td>13</td>
<td>Inspection</td>
<td>Visual, magnification, measurement, go/no-go, x-ray</td>
</tr>
<tr>
<td>14</td>
<td>Testing</td>
<td>In-circuit, physical, end-use, material testing</td>
</tr>
<tr>
<td>15</td>
<td>Reliability Stress Conditioning</td>
<td>Thermal Cycling, Vibration, Humidity Testing</td>
</tr>
</tbody>
</table>
The Handbook follows this format:

**Issue: Solder Mask-Defined and Non-Defined Lands**

<table>
<thead>
<tr>
<th>CAUSE</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interposer is solder mask defined; board is metal-defined. If the</td>
<td>Area of the two attachment conditions should be similar or identical.</td>
</tr>
<tr>
<td>two areas are very different the stresses are not uniform and</td>
<td>In addition, solder mask defined lands create additional stress and</td>
</tr>
<tr>
<td>cracks may occur at the solder mask defined side. Board land</td>
<td>should be avoided on both the interposer and the printed board land.</td>
</tr>
<tr>
<td>pattern too large.</td>
<td></td>
</tr>
</tbody>
</table>

**Potential test methods (discover)**

**Potential test method (verification)**

- X-Ray
- Cross section – Visual inspection

Where available, an illustration is included to aid in clearly identifying the problem.

General instruction may at times be provided. Text will be printed across the page, dealing with the subject in general, and not highlighting a problem, cause, or corrective action.

### 1.2 Guidelines for Effective Troubleshooting and Process Control

One of the keys to effective problem solving is a structured routine that addresses key points each time a major problem is encountered. This section suggests steps to be taken in order to effectively find the cause of a problem and to solve it permanently. Refer to IPC-9191 for greater detail to suggested methodology for Statistical Process Control.

1. **Problem Identification**
   - Before beginning a detailed troubleshooting project, use common sense in defining the problem. Verify that there is a problem. Observe the defective product and compare to the standard. Identify the standard process and product, and then determine any present deviation from the standard, or any change in the product.

2. **Establish whether operating procedures were followed**
   - and whether an assignable cause can be quickly identified as the reason behind the problem. Only continue into more detailed analysis if the initial questions do not lead to an obvious answer. Even if the answer appears to be obvious, confirm the answer by operation of the process before closing the project.

3. **Develop a clear, concise problem statement**
   - that quantifies the problem whenever possible and reduces the scope of the investigation to a manageable size.

4. **Gather all pertinent data and facts**
   - Use SPC, historical data, records, logs, etc. This includes temperature charts, analysis records, maintenance logs and the like.

5. **Use root cause analysis.**

6. **Producing out-of-specification parts require immediate action,** i.e., shut down the process.

7. **Out-of-control processes require determination as to whether the process can continue to operate.**

8. **Severe process variation requires evaluation of the severity and effect of the problem on the final product.**