



IPC-7711/7721

Revision C
January 2017

Rework, Modification and Repair of Electronic Assemblies

Supersedes Revision B
November 2007

An international standard developed by IPC

Association Connecting Electronics Industries



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IPC-7711C/7721C

Rework, Modification and Repair of Electronic Assemblies

Developed by the Repairability Subcommittee (7-34) of the Product Assurance Committee (7-30) of IPC

Supersedes:

IPC-7711/7721 with
Changes 1 and 2
Revision B - November 2007
Change 1 - February 2013
Change 2 - March 2014
IPC-7711A/7721A -
October 2003
IPC-R-700C -
January 1988

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

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Acknowledgment

Any document involving a complex technology draws material from a vast number of sources across many continents. While the principal members of the IPC Repairability Subcommittee (7-34) of the Product Assurance Committee (7-30) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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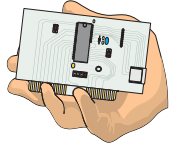
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Table of Contents

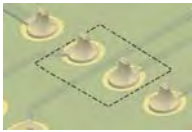
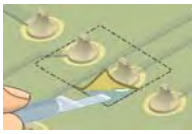
PART 1 General Information and Common Procedures

1 General	1	1.8.8 Hand Held Drilling and Grinding Tool	5
1.1 Scope	1	1.8.9 Precision Drill/Mill System	6
1.2 Purpose	1	1.8.10 Eyelets and Eyelet Press System	6
1.2.1 Definition of Requirements	1	1.8.11 Gold Plating System	6
1.3 Background	1	1.8.12 Tools and Supplies	6
1.4 Terms and Definitions	1	1.8.13 Materials	6
1.4.1 Class of Product	1	1.8.13.1 Solder	6
1.4.2 Board Types	2	1.8.13.2 Flux	6
1.4.3 Skill Level	2	1.8.13.3 Replacement Conductors and Lands	6
1.5 Applicability, Controls and Acceptability	2	1.8.13.4 Epoxy and Coloring Agents	6
1.5.1 Level of Conformance	2	1.8.13.5 Adhesives	6
1.5.1.1 Levels of Conformance	3	1.8.13.6 General	6
1.5.2 Compliance	3	1.8.14 Process Goals and Guidelines	6
1.6 Training	3	1.8.14.1 Nondestructive Component Removal	7
1.7 Basic Considerations	4	1.8.14.1.1 Surface Mount Components	7
1.8 Workstations, Tools, Materials and Processes	4	1.8.14.1.2 Through-Hole Components	7
1.8.1 Electrostatic Discharge (ESD) and Electrical Overstress (EOS) Controls	4	1.8.14.1.3 Component Removal Using Solder Fountain Method	7
1.8.2 Vision Systems	4	1.8.14.2 Component Installation	7
1.8.3 Lighting	4	1.8.14.2.1 Land Preparation	7
1.8.4 Fume Extraction	4	1.8.14.2.2 Surface Mount Components	7
1.8.5 Soldering Tools	4	1.8.14.2.3 Through-Hole Components	8
1.8.6 Primary Heating Methods	5	1.8.15 Cleaning Station/System	8
1.8.6.1 Conductive (by contact) Heating Methods	5	1.8.16 Component Removal and Installation	9
1.8.6.2 Convective (hot gas) and IR (radiant) Heating Methods	5	1.8.17 Conformal Coating Area	9
1.8.7 Preheating (Auxiliary) Heating	5	1.8.18 Selecting a Process	9
		1.8.19 Time Temperature Profile (TTP)	9
		1.9 Lead Free	9

Handling/Cleaning

Procedure	Description		Board Type	Skill Level	Level of Conformance
2.1	Handling Electronic Assemblies		N/A	N/A	N/A
2.2	Cleaning		N/A	N/A	N/A

Coating Removal

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
2.3.1	Coating Removal, Identification of Conformal Coating		R, F, W, C	Advanced	High
2.3.2	Coating Removal, Solvent Method		R, F, W, C	Advanced	High
2.3.3	Coating Removal, Peeling Method		R, F, W, C	Advanced	High
2.3.4	Coating Removal, Thermal Method		R, F, W, C	Advanced	High
2.3.5	Coating Removal, Grinding/Scraping Method		R, F, W, C	Advanced	High
2.3.6	Coating Removal, Micro Blasting Method		R, F, W, C	Advanced	High

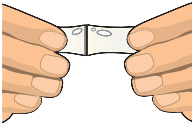
Coating Replacement

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
2.4.1	Coating Replacement, Solder Resist		R, F, W, C	Intermediate	High
2.4.2	Coating Replacement, Conformal Coatings/Encapsulants		R, F, W, C	Intermediate	High

Conditioning

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
2.5	Baking and Preheating		R, F, W, C	Intermediate	High

Epoxy Mixing and Handling

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
2.6	Epoxy Mixing and Handling		R, F, W, C	Intermediate	High

Legends/Markings

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
2.7.1	Legend/Marking, Stamping Method		R, F, W, C	Intermediate	High
2.7.2	Legend/Marking, Hand Lettering Method		R, F, W, C	Intermediate	High
2.7.3	Legend/Marking, Stencil Method		R, F, W, C	Intermediate	High

Tip Care and Maintenance

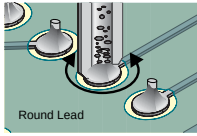
Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
2.8	Tip Care and Maintenance		N/A	N/A	N/A

Table of Contents

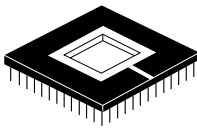
PART 2 Rework

3 Removal

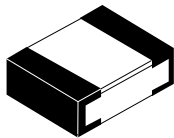
3.1 Through-Hole Desoldering

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.1.1	Continuous Vacuum Method		R,F,W	Intermediate	High
3.1.2	Continuous Vacuum Method - Partial Clinch		R,F,W	Intermediate	High
3.1.3	Continuous Vacuum Method - Full Clinch		R,F,W	Intermediate	High
3.1.4	Full Clinch Straightening Method		R,F,W	Intermediate	High
3.1.5	Full Clinch Wicking Method		R,F,W	Advanced	High

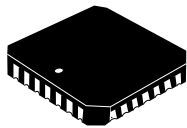
3.2 PGA and Connector Removal

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.2.1	Solder Fountain Method		R,F,W,C	Expert	High

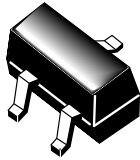
3.3 Chip Component Removal

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.3.1	Bifurcated tip		R,F,W,C	Intermediate	High
3.3.2	Tweezer Method		R,F,W,C	Intermediate	High
3.3.3	Including Bottom Termination - Hot Air Method		R,F,W,C	Intermediate	High

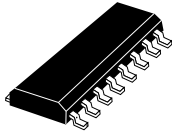
3.4 Leadless Component Removal

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.4.1	Solder Wrap Method - Tweezer		R,F,W,C	Advanced	High
3.4.2	Flux Application Method - Tweezer		R,F,W,C	Advanced	High
3.4.3	Hot Gas (Air) Reflow Method		R,F,W,C	Advanced	High

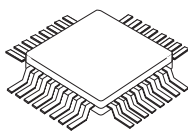
3.5 SOT Removal

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.5.1	Flux Application Method		R,F,W,C	Intermediate	High
3.5.2	Flux Application Method - Tweezer		R,F,W,C	Intermediate	High
3.5.3	Hot Air Pencil		R,F,W,C	Intermediate	High

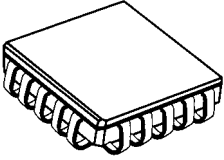
3.6 Gull Wing Removal (two-sided)

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.6.1	Bridge Fill Method		R,F,W,C	Intermediate	High
3.6.2	Solder Wrap Method		R,F,W,C	Intermediate	High
3.6.3	Flux Application Method		R,F,W,C	Intermediate	High
3.6.4	Bridge Fill Method - Tweezer		R,F,W,C	Advanced	High
3.6.5	Solder Wrap Method - Tweezer		R,F,W,C	Advanced	High
3.6.6	Flux Application Method - Tweezer		R,F,W,C	Advanced	High

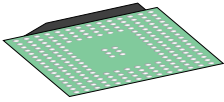
3.7 Gull Wing Removal (four-sided)

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.7.1	Bridge Fill Method - Vacuum Cup		R,F,W,C	Advanced	High
3.7.1.1	Bridge Fill Method - Surface Tension		R,F,W,C	Intermediate	High
3.7.2	Solder Wrap Method - Vacuum Cup		R,F,W,C	Advanced	High
3.7.2.1	Solder Wrap Method - Surface Tension		R,F,W,C	Intermediate	High
3.7.3	Flux Application Method - Vacuum Cup		R,F,W,C	Advanced	High
3.7.3.1	Flux Application Method - Surface Tension		R,F,W,C	Intermediate	High
3.7.4	Bridge Fill Method - Tweezer		R,F,W,C	Advanced	High
3.7.5	Solder Wrap Method - Tweezer		R,F,W,C	Advanced	High
3.7.6	Flux Application Method - Tweezer		R,F,W,C	Advanced	High
3.7.7	Hot Gas (Air) Reflow Method		R,F,W,C	Advanced	High

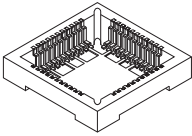
3.8 J-Lead Removal

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.8.1	Bridge Fill Method - Tweezer		R,F,W,C	Advanced	High
3.8.1.1	Bridge Fill Method - Surface Tension		R,F,W,C	Advanced	High
3.8.2	Solder Wrap Method - Tweezer		R,F,W,C	Advanced	High
3.8.2.1	Solder Wrap Method - Surface Tension		R,F,W,C	Advanced	High
3.8.3	Flux Application Method - Tweezer		R,F,W,C	Advanced	High
3.8.4	Flux & Tin Tip Only		R,F,W,C	Advanced	High
3.8.5	Hot Gas Reflow System		R,F,W,C	Advanced	High

3.9 BGA/CSP Removal

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.9.1	Hot Gas Reflow System		R,F,W,C	Advanced	High
3.9.1.2	Focused IR Reflow Systems (with integral preheater)		R,F,W,C	Advanced	High
3.9.2	Vacuum Method		R,F,W,C	Advanced	Medium

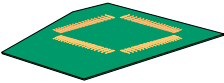
3.10 PLCC Socket Removal

Procedure	Description		Board Type	Skill Level	Level of Conformance
3.10.1	Bridge Fill Method		R,F,W,C	Advanced	High
3.10.2	Solder Wrap Method		R,F,W,C	Advanced	High
3.10.3	Flux Application Method		R,F,W,C	Advanced	High
3.10.4	Hot Air Pencil Method		R,F,W,C	Advanced	Medium

3.11 Bottom Terminated Component Removal

Procedure	Description	Board Type	Skill Level	Level of Conformance
3.11.1	Hot Air Method	R,F,C	Expert	Medium

4 Pad/Land Preparation

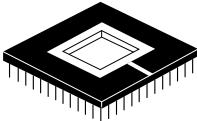
Procedure	Description		Board Type	Skill Level	Level of Conformance
4.1.1	Surface Mount Land Preparation - Individual Method		R,F,W,C	Intermediate	High
4.1.2	Surface Mount Land Preparation - Continuous Method		R,F,W,C	Intermediate	High
4.1.3	Surface Solder Removal - Braid Method		R,F,W,C	Intermediate	High
4.2.1	Pad Releveling - Using Blade Tip		R,F,W,C	Intermediate	High
4.3.1	SMT Land Tinning - Using Blade Tip		R,F,W,C	Intermediate	Medium
4.4.1	Cleaning SMT Lands - Using Blade Tip and Solder Braid		R,F,W,C	Intermediate	High

5 Installation

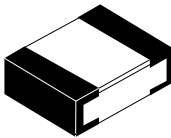
5.1 Through-Hole Installation

Procedure	Description	
	Install following the requirements of J-STD-001 and IPC-HDBK-001	

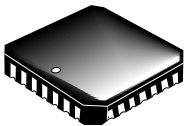
5.2 PGA and Connector Installation

Procedure	Description		Board Type	Skill Level	Level of Conformance
5.2.1	Solder Fountain Method with PTH Prefilled		R,F,W,C	Expert	High

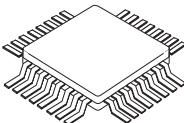
5.3 Chip Installation

Procedure	Description		Board Type	Skill Level	Level of Conformance
5.3.1	Solder Paste Method/Hot Air Pencil		R,F,W,C	Intermediate	High
5.3.2	Point-to-Point Method		R,F,W,C	Intermediate	High

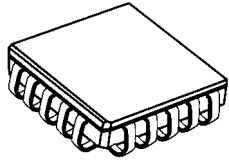
5.4 Leadless Component Installation

Procedure	Description		Board Type	Skill Level	Level of Conformance
5.4.1	Hot Gas (Air) Reflow Method		R,F,W,C	Advanced	High

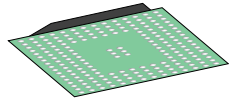
5.5 Gull Wing Installation

Procedure	Description		Board Type	Skill Level	Level of Conformance
5.5.1	Multi-Lead Method - Top of Lead		R,F,W,C	Advanced	High
5.5.2	Multi-Lead Method - Toe Tip		R,F,W,C	Advanced	High
5.5.3	Point-to-Point Method		R,F,W,C	Intermediate	High
5.5.4	Solder Paste Method/Hot Air Pencil		R,F,W,C	Advanced	High
5.5.5	Hook Tip w/Wire Layover		R,F,W,C	Intermediate	High
5.5.6	Blade Tip with Wire		R,F,W,C	Advanced	Medium
5.5.7	Adhesive Backed Stencil, Solder Paste Method/Hot Air		R,F,W,C	Advanced	High

5.6 J-Lead Installation

Procedure	Description		Board Type	Skill Level	Level of Conformance
5.6.1	Solder Wire Method		R,F,W,C	Advanced	High
5.6.2	Point-to-Point Method		R,F,W,C	Intermediate	High
5.6.3	Solder Paste Method/Hot Air Pencil		R,F,W,C	Advanced	High
5.6.4	Multi-Lead Method		R,F,W,C	Intermediate	High

5.7 BGA/CSP Installation

Procedure	Description		Board Type	Skill Level	Level of Conformance
5.7.1	Using Solder Wire to Prefill Lands		R,F,W,C	Advanced	High
5.7.1.2	Focused IR Reflow System (with integral preheater)		R,F,W,C	Advanced	High
5.7.2	Using Solder Paste to Prefill Lands		R,F,W,C	Advanced	High
5.7.2.1	Stay-in-Place Stencil		R,F,C	Advanced	Medium
5.7.3	BGA Reballing Procedure - Fixture Method		R,C	Advanced	High
5.7.4	BGA Reballing Procedure - Paper Carrier Method		R,C	Advanced	High
5.7.5	BGA Reballing Procedure - Polyimide Stencil Method		R,C	Advanced	High
5.7.6	Polyimide Solder Ball Stencil Carrier		R,C	Advanced	High

5.8 Bottom Terminated Device

Procedure	Description	Board Type	Skill Level	Level of Conformance
5.8.1.1	Installation Pre-bump and place	R,F,C	Expert	Medium
5.8.1.2	Installation Pre-bump and place with stay in place stencil	R,F,C	Expert	Medium
5.8.1.3	Installation Pre-Hand soldering plus centered ground bump	R,F,C	Expert	Medium

6 Removing Shorts

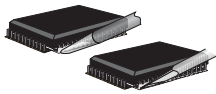
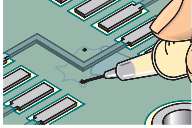
Procedure	Description		Board Type	Skill Level	Level of Conformance
6.1.1	J-Leads - Draw Off Method		R,F,W,C	Intermediate	High
6.1.2	J-Leads - Respread Method		R,F,W,C	Intermediate	High
6.1.2.1	J-Leads - Braid Method		R,F,W,C	Intermediate	High
6.1.3	Gull-Wing - Draw Off Method		R,F,W,C	Intermediate	High
6.1.4	Gull-Wing - Respread Method		R,F,W,C	Intermediate	High
6.1.4.1	Gull-Wing - Braid Method		R,F,W,C	Intermediate	High

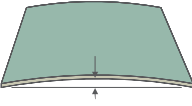
Table of Contents

PART 3 Modification and Repair

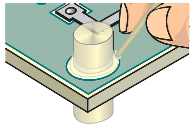
Blisters and Delamination

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
3.1	Delamination/Blister Repair, Injection Method		R	Advanced	High

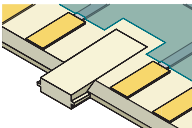
Bow & Twist

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
3.2	Bow and Twist Repair		R, W	Advanced	Medium

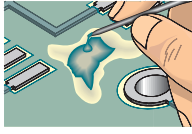
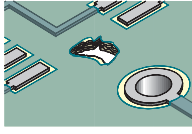
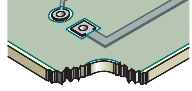
Hole Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
3.3.1	Hole Repair, Epoxy Method		R, W	Advanced	High
3.3.2	Hole Repair, Transplant Method		R, W	Expert	High

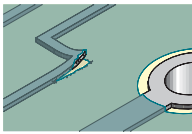
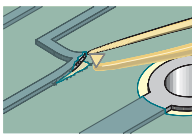
Key and Slot Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
3.4.1	Key and Slot Repair, Epoxy Method		R, W	Advanced	High
3.4.2	Key and Slot Repair, Transplant Method		R, W	Expert	High

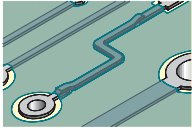
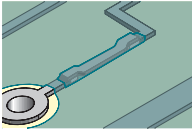
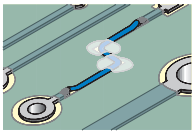
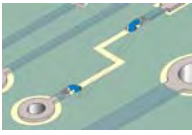
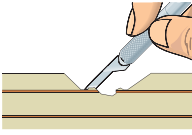
Base Material Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
3.5.1	Base Material Repair, Epoxy Method		R, W	Advanced	High
3.5.2	Base Material Repair, Area Transplant Method		R, W	Expert	High
3.5.3	Base Material Repair, Edge Transplant Method		R, W	Expert	High

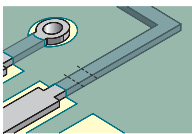
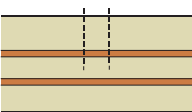
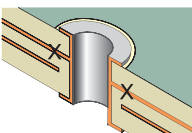
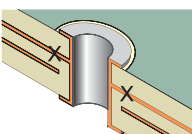
Lifted Conductors

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
4.1.1	Lifted Conductor Repair, Epoxy Seal Method		R, F	Intermediate	Medium
4.1.2	Lifted Conductor Repair, Film Adhesive Method		R, F	Intermediate	High

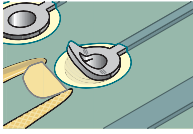
Conductor Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
4.2.1	Conductor Repair, Foil Jumper, Epoxy Method		R, F, C	Advanced	Medium
4.2.2	Conductor Repair, Foil Jumper, Film Adhesive Method		R, F, C	Advanced	High
4.2.3	Conductor Repair, Welding Method		R, F, C	Advanced	High
4.2.4	Conductor Repair, Surface Wire Method		R, F, C	Intermediate	Medium
4.2.5	Conductor Repair, Through Board Wire Method		R	Advanced	Medium
4.2.6	Conductor Repair/Modification, Conductive Ink Method		R, F, C	Expert	Medium
4.2.7	Conductor Repair, Inner Layer Method		R, F	Expert	High

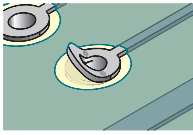
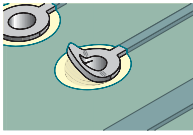
Conductor Cut

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
4.3.1	Conductor Cut, Surface Conductors		R, F	Advanced	High
4.3.2	Conductor Cut, Inner Layer Conductors		R, F	Advanced	High
4.3.3	Deleting Inner Layer Connection at a Plated Hole, Drill Through Method		R, F	Advanced	High
4.3.4	Deleting Inner Layer Connection at a Plated Hole, Spoke Cut Method		R, F	Advanced	High

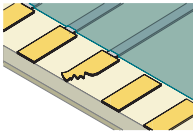
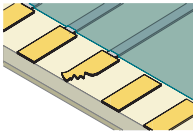
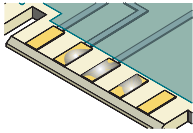
Lifted Land Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
4.4.1	Lifted Land Repair, Epoxy Method		R, F	Advanced	Medium
4.4.2	Lifted Land Repair, Film Adhesive Method		R, F	Advanced	Medium

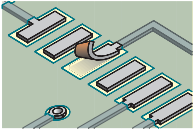
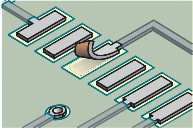
Land Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
4.5.1	Land Repair, Epoxy Method		R, F	Advanced	Medium
4.5.2	Land Repair, Film Adhesive Method		R, F	Advanced	High

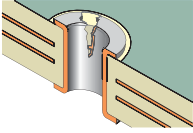
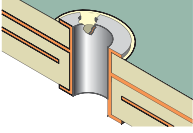
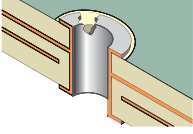
Edge Contact Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
4.6.1	Edge Contact Repair, Epoxy Method		R, F, W, C	Advanced	Medium
4.6.2	Edge Contact Repair, Film Adhesive Method		R, F, W, C	Advanced	High
4.6.3	Edge Contact Repair, Plating Method		R, F, W, C	Advanced	High

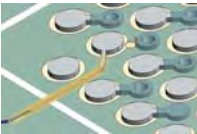
Surface Mount Pad Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
4.7.1	Surface Mount Pad Repair, Epoxy Method		R, F, C	Advanced	Medium
4.7.2	Surface Mount Pad Repair, Film Adhesive Method		R, F, C	Advanced	High
4.7.3	Surface Mount, BGA Pad Repair, Film Adhesive Method		R, F, C	Advanced	High
4.7.4	Surface Mount, BGA Land with Integral Via Repair Film Adhesive Method		R,F	Expert	Medium
4.7.4.1	Surface Mount Pad with Integral Via Repair Film Adhesive Method - No Conductor Bend		R,F	Expert	Medium
4.7.5	Surface Mount, BGA Land with Integral Via Repair Circuit Extension Film Adhesive Method		R,F,C	Expert	High

Plated Hole Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
5.1	Plated Hole Repair, No Inner Layer Connection		R, F, W	Intermediate	High
5.2	Plated Hole Repair, Double Wall Method		R, F, W	Advanced	Medium
5.3	Plated Hole Repair, Inner Layer Connection		R	Expert	Medium
5.4	Plated Hole Repair, No Inner Layer Connection, Clinched Jumper Wire Method		R,F,W	Intermediate	Medium

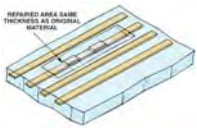
Jumpers

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
6.1	Jumper Wires		R, F, W, C	Intermediate	N/A
6.2.1	Jumper Wires, BGA Components, Foil Jumper Method		R, F	Expert	Medium
6.2.2	Jumper Wires, BGA Components, Through Board Method		R, F	Expert	High

Component Additions

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
6.3	Component Modifications and Additions		R, F, W, C	Advanced	N/A

Flexible Conductor Repair

Procedure	Description	Illustration	Board Type	Skill Level	Level of Conformance
7.1.1	Flexible Conductor Repair		F	Expert	Medium

8 Wires**8.1 Splicing**

Procedure	Description		Board Type	Skill Level	Level of Conformance
8.1.1	Mesh Splice		N/A	Intermediate	Low
8.1.2	Wrap Splice		N/A	Intermediate	Low
8.1.3	Hook Splice		N/A	Intermediate	Low
8.1.4	Lap Splice		N/A	Intermediate	Low

General Information and Common Procedures

1.1 Scope This document covers procedures for repairing and reworking printed board assemblies. It is an aggregate of information collected, integrated and assembled by the Repairability Subcommittee (7-34) of the Product Assurance Committee of the IPC. This revision includes expanded coverage for lead free processes, and additional inspection guidelines for operations such as repair that may not have other published criteria.

This document does not limit the maximum number of rework, modification or repair actions to a Printed Circuit Assembly.

1.2 Purpose This document prescribes the procedural requirements, tools, materials and methods to be used in the rework, repair, modification, overhaul or restoration of electronic products. Although this document is based in large part on the Product Class definitions used in IPC documents such as J-STD-001 or IPC-A-610, this document should be considered applicable to any type of electronic equipment. When invoked by contract as the controlling document for the rework, repair, modification, overhaul or restoration of products, the requirements flow-down apply.

IPC has identified the most common equipment and process in order to perform a specific repair or rework. It is possible that alternate equipment and processes can be used to make the same repair/rework. If alternate equipment or processes are used, it is up to the user to ensure the equipment/processes do not damage the assembly and meet the intent of Section 1.5.1.1 (Levels of Conformance) for the alternate equipment/processes utilized.

1.2.1 Definition of Requirements This document is intended to be used as a guide and there are no specific requirements or criteria unless separately and specifically called out in a user's contractual or other documentation. When statements such as "must," "should" or "need to be" are used, they are stressing an important point. If these strong recommendations are not followed, the end result may not be satisfactory and additional damage could be caused.

Arrows in the rework procedures are either up or down describing the type of rework procedure being conducted. An up arrow means removal and a down arrow means installing.

1.3 Background Today's electronic assemblies are more complex and smaller than ever before. Despite this, they can be successfully reworked, repaired or modified if the

proper techniques are followed. This manual is designed to help users rework, repair and/or modify electronic assemblies with minimum impact on end use functionality or reliability. The procedures in this document have been obtained from assemblers, printed board manufacturers and users who recognize the need for documenting commonly used rework, repair and modification techniques. These techniques have, in general, been proven to be acceptable for the class of product indicated through testing and extended field functionality. Procedures contained herein were submitted for inclusion by commercial and military organizations too numerous to list individually. The Repairability Subcommittee has, where appropriate, revised procedures to reflect improvements.

1.4 Terms and Definitions The following definitions apply to the use of this document.

PCA – Printed Circuit Assembly

Rework – the act of reprocessing noncomplying articles, through the use of original or equivalent processing, in a manner that assures full compliance of the article with applicable drawings or specifications.

Modification – the revision of the functional capability of a product in order to satisfy new acceptance criteria. Modifications are usually required to incorporate design changes which can be controlled by drawings, change orders, etc. Modifications should only be performed when specifically authorized and described in detail on controlled documentation.

Repair – the act of restoring the functional capability of a defective article in a manner that does not assure compliance of the article with applicable drawings or specifications.

Tack Solder – A solder connection commonly used to temporarily align and retain a multilead component in place on a PCB during the soldering of the other leads. A tack solder connection typically requires additional reflow to form the final solder connection.

1.4.1 Class of Product The user of the product is responsible for identifying the Class of Product. The procedure selected for action to be taken (rework, repair, modification, ...) must be consistent with the Class identified by the user. The three Classes of Product are:

Class 1 – General Electronic Products

Includes products suitable for applications where the major requirement is the function of the completed assembly.



Class 2 – Dedicated Service Electronic Products

Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end use environment would not cause failures.

Class 3 – High Performance/Harsh Environment Electronic Products

Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support and other critical systems.

1.4.2 Board Types There are a variety of printed board types that the procedures in this document apply to. When selecting the appropriate rework, repair or modification procedure, the printed board type being worked should be considered. Select a procedure that applies to the printed board type as listed on the procedure. Printed board types include the following:

- R. *Rigid Printed Boards and Assemblies* – A printed board or assembly using rigid base materials only. These may be single-sided, double-sided or multilayered, and may be constructed from base laminate material that spans all approved commercial grades of laminate and includes glass fabric reinforced epoxy and polyimide resin laminates.
- F. *Flexible Printed Boards and Assemblies* – A printed board or assembly using flexible or a combination of rigid and flexible materials, which may utilize electrically nonfunctional stiffeners and/or cover layers. These may be single-sided, double-sided or multilayered.
- W. *Discrete Wiring Boards and Assemblies* – A printed board or assembly using a discrete wiring technique to obtain electrical interconnections.
- C. *Ceramic Boards and Assemblies* – A printed board or assembly using ceramic as the base material with interconnections separated by dielectric. The board layers are usually formed by alternate printing or depositing of interconnections and dielectric. The assemblies are either surface mount or die attach. Usually multilayered, these may be single-sided or double-sided.

1.4.3 Skill Level To assist in determining the skill level needed for each procedure, a Skill Level indicator is included in each process. The Skill Level recommended should be used as a guide only. Skill levels will vary widely from technician to technician and from company to company. These recommendations come from industry experience and are not necessarily backed up with substantive testing. Skills are separated into three categories.

- I. *Intermediate* – Technician with skills in basic soldering and component rework but inexperienced in general repair/rework procedures.
- A. *Advanced* – Technician with soldering and component rework skills and exposure to most repair/rework procedures but lacking extensive experience.
- E. *Expert* – Technician with advanced soldering and component rework skills and extensive experience in most repair/rework procedures.

1.5 Applicability, Controls and Acceptability Although the terms rework, repair and modification may seem very similar, applicability of such procedures may not be the same due to conditions and objectives involved. Procedures and guidelines of this document may be used during manufacturing of products or to products that have been delivered and/or failed in use.

In general, rework, repair or modification controls during manufacturing are different from the controls applied to products that fail after being placed in service and should be considered when dispositioning hardware.

When a defect or functional problem is discovered during the assembly process, a decision has to be made whether to rework or repair the product, use it as is, or discard it. Other than rework, this decision is typically the responsibility of a Material Review Board (MRB) as discussed in various assembly standards.

When a product fails after it has been placed in service, the term “repair” is commonly applied to actions taken in the service environment that restore operational use. Unlike the manufacturing process, there is no Material Review Board to disposition the failed assembly. How that decision is made is beyond the scope of this document.

When a disposition decision has been made that involves removing and replacing a failed component, the rework procedures in Part 2 - 7711 would be applicable. If a repair or modification is needed, the procedures in Part 3 - 7721 would be applicable.

1.5.1 Level of Conformance The Level of Conformance ratings provide the means for selecting a procedure with an appropriate level of conformance to the original electrical, mechanical, physical, environmental and visual product requirements. Each procedure lists a Level of Conformance that the product should attain when successfully completed. The Level of Conformance rating for each procedure is based on the skill of the technician, and is based on long term industry experience and are not necessarily backed up with testing data.

1.5.1.1 Levels of Conformance

- L. Lowest Level* – Significant variance with the physical character of the original and may vary with many of the electrical, functional, environmental and serviceability factors.
- M. Medium Level* – Some variance with the physical character of the original and most likely varies with some of the functional, environmental and serviceability factors.
- H. Highest Level* – Most closely duplicates the physical characteristics of the original and most probably complies with all the functional, environmental and serviceability factors.

Class 3 Products must use procedures rated Highest level unless it can be demonstrated that a lower level procedure will not adversely affect the product's functional characteristics. Class 2 and 1 Products should use procedures rated Highest level for assured safety and dependability but Medium and Low Level procedures can be used if it has been determined that they are suitable for the specific product's functional characteristics. Procedures in this manual are given a "Level of Conformance" rating which is described in Table 1.

Table 1 Level of Conformance

Functional Consideration	Level of Conformance		
	L	M	H
Electrical - Resistance	No	Verify	Yes
Electrical - Inductance	No	Verify	Yes
Electrical - Capacitance	No	Verify	Yes
Electrical - Cross Talk	No	Verify	Yes
Electrical - High Speed Frequency	No	Verify	Yes
Environmental - Shock	No	Verify	Yes
Environmental - Vibration	No	Verify	Yes
Environmental - Humidity	Verify	Verify	Yes
Environmental - Temperature	Yes	Yes	Yes
Environmental - Altitude	Verify	Verify	Verify
Environmental - Bacteria	Verify	Verify	Yes
Environmental - Fungus	Verify	Verify	Yes
Serviceability - Future Repair or Mod.	No	Yes	Yes

No Procedure may not comply with functional consideration.
 Verify Procedure should comply with functional consideration but should be tested to verify.
 Yes Procedure will normally comply with functional consideration.

In principle any rework, repair or modification action taken on a product should reestablish the products original character, "Make it like it was." Physical changes, obvious or otherwise, can adversely affect the products performance or capability factors.

1.5.2 Compliance Products that have been subjected to rework need to comply with the functional requirements for the product and any other attributes that may be required by the customer. In the absence of other defined acceptability criteria, it is appropriate to apply the acceptance criteria of J-STD-001 and/or IPC-A-610 to the reworked actions.

Modification and repair, by their nature, do not have industry established requirements and acceptance criteria. These will need to be determined on a case by case basis. Products that have been subjected to modification need to comply with the requirements of the engineering data package that defines the modification.

Repair or modification may result in, or include, minor changes in visual appearance that do not degrade the form, fit, or function of the assembly.

1.6 Training The quality and reliability of modified or repaired printed boards and assemblies is highly dependent upon the skill and competence of the person performing these tasks. The implementation of proper methods by unqualified personnel can result in a substandard end product. Consequently, achieving successful results with the methods described herein is predicated on the use of properly trained personnel whose skills have been tested and certified to be of a sufficient level of competence.

- Soldering Skills* – Many companies have considered assembly personnel who are competent in soldering techniques to be sufficiently trained for rework/repair activities. This has often been proven to be erroneous, as proper soldering is just one of the skills required. Additionally, in order to attain comparable results, there are many instances where component rework may require techniques that are different than those used to originally solder the component.
- Personnel Selection* – The proper selection of trainees will contribute significantly toward the success in developing capable repair personnel. Personnel with above average soldering abilities and sound reasoning capabilities often make ideal trainees. However, personnel who have no soldering skills, but possess a good level of visual acuity, manual dexterity, and sound reasoning capability, often can be successfully trained as well.
- Professional Training* – Companies should establish and maintain procedures for identifying the training needs and provide for the training of all personnel performing the activities affecting product quality. Personnel performing specific assigned tasks shall be qualified on the basis of appropriate education, training and experience. Maintaining records of training is appropriate and may be specifically required to meet International Organization for Standardization (ISO) or other quality certification criteria.

Training for personnel and instructors for the application of the methods and procedures in this document, is commercially available and can be completed by an outside organization specializing in the applicable discipline. Rework, repair or modification training employs concepts, techniques, procedures and a vocabulary that distinguishes it from basic soldering training. Effective training requires the development of high levels of comprehension and reasoning within the trainee. This necessitates expansive teaching methods and detailed demonstration under close instructor supervision, to help assure the development of proficiency within each trainee.

Training to establish a desired level of proficiency can usually be achieved after three to ten days of training, depending on the content of the training program, the complexity of the end product, and the proficiency of the trainee. Testing and certification can be provided for each trainee, as the situation warrants.

1.7 Basic Considerations

1. *Appropriate Approvals* – When rework, repair, or modification of products is conducted during manufacturing, appropriate approvals may be required. Unless prohibited by the customer, rework during manufacturing may usually be performed without prior approval of the customer. Repair actions and modifications generally require prior approval by the customer.
2. *Singular Procedures* – Procedures in this book are presented as individual methods. Multiple procedures may be necessary to complete the task
3. *Quality* – Rework, repair, or modification of printed boards and assemblies should achieve the quality of the original product.
4. *Procedure Selection* – The procedure selected should be on the basis of optimum end product functionality. It may be necessary to develop specific evaluation criteria depending on the product's required functions and end use environment.
5. *Patience* – To achieve best results, do not rush the process. Keep in mind that most of the cost for fabrication/assembly has already been spent, but with care and patience, most of this cost can be salvaged.
6. *Heat Application* – Incorrect heat application may cause severe damage to board materials, conductors, components, conformal coatings and solder connections. Additionally, careful consideration should be taken when selecting the equipment and/or application process to minimize the potential risk of damage caused by excessive heat.
7. *Removal of Coatings* – Coating should be removed from affected areas prior to processing. Coatings will inhibit solder removal and adversely affect resoldering operations.

1.8 Workstations, Tools, Materials and Processes Rework, repair or modification of printed circuit boards and assemblies is generally a highly labor intensive operation relying more on individual operator skills than automation. The use of proper tools and supplies, many unique to repair actions, will often have a significant impact on the function and reliability of the end product. To enhance the ease of the task at hand and to improve the potential for a successful operation, the following tools, materials, and processes may be required.

1.8.1 Electrostatic Discharge (ESD) and Electrical Overstress (EOS) Controls ESD is the rapid flow of electricity between objects with different potential. EOS is the internal damage that may occur when an electronic device is subjected to a current or voltage that is beyond the specification limits of the device. For more information on ESD and EOS, see Procedure 2.1.

1.8.2 Vision Systems The small features in electronic assemblies and the precision needed require use of a vision magnification system. Appropriate vision systems that provide depth perception, magnification, resolution, field of view and working distance are critical when performing rework, repair or modifications on the miniature components, circuits, and assemblies. Refer to IPC-OI-645 Standard for Visual Optical Inspection Aids for more information.

1.8.3 Lighting The circuit assembly needs to be illuminated with sufficient light to see the features and color variations. A typical minimum acceptable lighting level is at least 1000 Lm/m². In selecting a light source, the color temperature of the light is an important consideration. Light ranges from 3000 - 5000 K enable users to differentiate various metal alloys and contaminants. A black light assists in identifying flux residue and the presence of some types of conformal coating.

1.8.4 Fume Extraction Work environments can often expose technicians to potentially hazardous fumes. Disposal and release of certain materials may have a significant environmental impact. The use of localized fume extraction systems, environmental control devices and other personnel protection equipment may be necessary to comply with SDS (safety data sheets) requirements and applicable federal, state and local laws.

1.8.5 Soldering Tools Precision soldering is important in today's rework, repair or modification operations. Technicians may need an assortment of specialty soldering tools appropriate for the variety of tasks at hand. It is important that all tools used that are required to be calibrated be checked prior to use. In general, these tools must be temperature controlled, ESD/EOS safe, ergonomically designed and include a selection of tips.

particular operation. Additionally, these tools typically use conductive heating (by contact), convective heating (by hot gas) or infrared heating (by focused infrared lamps) as the primary heat source.

1.8.6 Primary Heating Methods Primary heating methods are those principally responsible for achieving solder reflow during a component installation or removal process. These are to be distinguished from methods used for preheating and auxiliary heating which are employed in addition to primary heating methods.

1.8.6.1 Conductive (by contact) Heating Methods For conductive heating tools and methods to work effectively, the heated contact surface must be kept clean and free of oxidation (see Common Procedure 2.8 for soldering iron tip maintenance).

Soldering iron temperature control is categorized into one of three types:

- *Fixed Temperature Irons* – Do not permit changing the tip temperature.
- *Selectable Temperature Irons* – Selectable temperature soldering irons permit operation at a preselected temperature. Selection of the temperature is achieved by removal/replacement of an integrated part of the soldering system (soldering iron tip, temperature control module, etc.). Typically a selectable temperature soldering iron offers temperature selection in 50 or 100 degree increments.
- *Variable Temperature Irons* – Variable temperature soldering irons permit operation at any temperature within the control range (typically 260 - 427 °C [500 - 800 °F]). Temperature selection may be achieved by either digital or analog control.

Additional examples of conductive tools are:

- *Soldering Tweezers* – Common name for a tool that simultaneously uses two separate elements to achieve reflow of a solder connection. Soldering tweezers fall into one of two categories:
 - *Thermal Tweezers* – A tweezer handpiece that has each tweezer tip heated to a predetermined temperature. Thermal tweezers are typically used for removing SMT components from a PCB.
 - *Resistive Tweezers* – A tweezer handpiece that has a different electrical potential on each tweezer tip. Heating is achieved by passing a high density electrical current between the tips (through the item being soldered). Resistive tweezers are typically used for soldering cup terminals and similar components that will not be damaged by the voltage and current present in the soldering action.
- *Solder Pots/Fountains* – The alloy type, contamination levels, and temperatures need to be monitored to assure they are compatible with the work being performed.

1.8.6.2 Convective (hot gas) and IR (radiant) Heating Methods

Examples of convective tools are:

- *Hot Air Pencil* – Common name for the handpiece used to deliver heated gas to connection elements to be soldered. Typically used to reflow solder paste, but can also be used with solder wire.
- *Hot Air Gun* – Common name for the handpiece used to deliver heated gas to connection elements to be soldered. Similar in concept to the hot air pencil but usually with greater thermal capacity.
- *Benchtop Work Stations* – Convective, IR or a combination of the heating methods.

1.8.7 Preheating (Auxiliary) Heating Preheating printed board assemblies is sometimes recommended to avoid thermal shock to temperature sensitive materials and components. Preheating also elevates the thermal mass of the assembly to allow a rework process to proceed in an acceptable time frame. Preheating can be accomplished using either an oven, heat lamp, hot plate, infrared or convective style heating system.

Preheating is required when there is a risk of thermal shock in the substrate, components or both. The goal is to ramp up the assembly and/or component at an acceptably safe rate. The rate of “ramp up” can be critical. For example, many ceramic chip capacitor manufacturers have traditionally recommended that preheating occur at a rate of no greater than 2 - 4 °C/sec until a given minimum temperature is reached. Refer to manufacturers data sheets for additional information. The assembly (or component) is then thermally soaked. This eliminates dangerous temperature gradients which could produce immediate damage, degradation over time or reduction of reliability.

Preheating/auxiliary heating is also required when the primary heating method cannot bring all of the solder joints completely up to reflow temperature at all, or in an acceptable period of time. This may be due to the high mass of the components in question, and/or heat sinking by nearby portions of the substrate, circuit elements or adjacent components. The goal is to bring the assembly (or a portion thereof) up to a sufficient (yet safe) temperature at which the rate of heat sinking is low enough that the primary heating method can attain proper solder reflow in an acceptable period of time. This process may also be used for through-hole desoldering on heavy multilayer boards with internal ground planes. For moisture removal see Common Procedure 2.5.

1.8.8 Hand Held Drilling and Grinding Tool PC Board rework, repair or modification procedures often require drilling, milling or grinding operations. The best type of tool for these delicate operations is preferably a lightweight, high quality, EOS/ESD controlled motorized rotary tool. This tool can be used for detailed work (i.e., solder resist and conformal coating removal, grinding on pins

laminates, defects, drilling out plated holes, cutting fine pitch conductors, etc.).

1.8.9 Precision Drill/Mill System Advanced PCB rework, repair or modification procedures often require extremely accurate drilling, milling and grinding operations requiring precise speed and depth control. A precision milling/drilling system along with fixture hardware or gantry to securely retain the PCB will allow for precise X/Y axis positioning and Z axis control. Precision milling/drilling systems should have an attached microscope to ensure accuracy and/or be software controlled. For extremely demanding subtractive (material removal) procedures, use of lasers is a consideration.

1.8.10 Eyelets and Eyelet Press System Solder plated copper eyelets and an eyelet press/setting tool to repair damaged plated-through holes may be required. The use of eyelets and press system may require customer approval.

1.8.11 Gold Plating System Plating gold edge contacts or any other metal surface requires the use of materials that may have environmental and safety concerns and must be handled properly. The power applied to the plating surfaces must be controlled accurately to expect reliable results. Plating systems typically include: a DC power supply with voltage and current meters, plating anodes sized for gold edge contact plating, a solution tray to collect the solution runoff, a support for the PC board and a tray to hold and store the various chemicals safely.

1.8.12 Tools and Supplies In addition, a wide assortment of hand tools including tweezers, various pliers, files, dental picks, cutting tools and other common items may be needed to execute these various rework, repair or modification procedures.

1.8.13 Materials The materials listed are “generic” in nature. It is recommended that these materials are available and approved for use by your company and should be included in a documented process control plan. The use of some of these materials includes some increased risk (fire, personnel safety, etc.) and accordingly, should not be used unless appropriate safety precautions are enforced.

1.8.13.1 Solder The procedures in this document are not specific to any alloy type and should be compatible with most commonly used tin-lead or lead-free alloys. When soldering on newly manufactured assemblies the same alloy type needs to be used. When attempting repairs of fielded assemblies, it may be impossible to determine the alloy type. It is recommended that you look at drawings, labeling or any available documentation for the assembly to attempt to determine the correct alloy to use. When unknown and without other direction, the standard alloy

used in your facility should be used. IPC/JEDEC J-STD-609 (supersedes IPC-1066) is an example of a standard used to identify the solder alloys and coatings on the assembly. See Section 1.9.

1.8.13.2 Flux The type of flux used needs to be appropriate to the solder alloy/process being used, and compatible with the cleaning and coating processes that may be required.

1.8.13.3 Replacement Conductors and Lands There are commercially available replacement conductors and lands that are normally fabricated from copper foil and plated with solder or nickel and gold for edge contact repair. These conductors and lands are available with or without a dry film adhesive on the back. Adhesive-backed conductors and lands are normally heat-bonded to the board surface. Replacement conductors and lands are available in various shapes, sizes and thicknesses. Compatible replacement conductors and features may also be salvaged from scrap Printed Circuit boards, if necessary.

1.8.13.4 Epoxy and Coloring Agents Many repair operations require the use of high strength, high temperature epoxies. For high temperature applications two-part epoxies offer the highest strength, thermal resistance and durability. It may also be important to have resists or coloring agents so that you can restore the cosmetic appearance of the board. It is best to cure the epoxies in an oven if possible.

1.8.13.5 Adhesives The type of adhesive used needs to be appropriate to the purpose of the adhesive, whether for thermal management or for attachment of an item such as a heat sink, replacement land/conductor, jumper wires, etc. Issues that need to be considered are shelf life of the material, mixing ratios, working life, curing, and compatibility with cleaning and coating processes that may be required.

1.8.13.6 General Any consumables such as wicking braid, wipes and other items listed in the procedures need to be compatible with the process.

1.8.14 Process Goals and Guidelines The process of component replacement involves three basic procedures: component removal, land preparation and component installation. Additionally, depending on PCA configuration, conformal coating removal and replacement may also be required.

a. *Nondestructive Process* – During any assembly or rework process, no damage or degradation should occur to the board (both substrate and circuit elements), adjacent components, and the component(s) being installed or removed. This potential damage or degradation to the product may be either mechanical, thermo/mechanical or purely thermal in nature and may be

in either immediate failure, degradation in performance over time (latent failure), or a reduction in reliability. EOS/ESD damage must also be avoided by employing proper work procedures, work stations and equipment controls.

- b. *Controllable, Reliable and Repeatable Process* – The process can be employed, and when necessary, modified by a trained operator in a repetitive fashion with consistently acceptable results.
- c. *Process Appropriate to Particular Application* – The process (or modification thereof) employed is appropriate to the particular application based on the relevant guidelines described below.
- d. *Operator-Friendly Process* – An operator of average ability can, with proper training and practice, become acceptably proficient in employing, and when required, modifying the process to suit any particular requirements of a given task.
- e. *Efficient Process* – The process can be done repeatedly in a production environment quickly and easily at minimal costs with little or no down-time.

1.8.14.1 Nondestructive Component Removal In many cases, parts may need to have failure analysis testing performed on them, which would require the application of a non-destructive removal process. During this process, the operator cannot induce damage to the substrate of other areas on the assembly as a result of the method or tools used for component removal. Each rework-modification-repair procedure has certain advantages, disadvantages and precautions. These depend on the particular operation/device/material (lead/terminations design, size, body material, etc.), component mounting site (adjacent components, access, substrate type, thermal mass, etc.) and the skill level of the operator. Some procedures depicted in this document may not be applicable to all termination styles.

1.8.14.1.1 Surface Mount Components

- Preheat/auxiliary heat assembly and/or component, if required.
- Evenly apply heat in a rapid, controllable fashion to achieve complete, simultaneous reflow (melt) of all solder joints.
- Avoid thermal and/or mechanical damage to component, board, adjacent components and their joints.
- Immediately remove component from board before any solder joint resolidifies.
- Prepare lands for replacement component.

1.8.14.1.2 Through-Hole Components Desolder component one joint at a time using vacuum method:

- Pre/auxiliary heat assembly and/or component, if required.
- Heat joint in a rapid, controllable fashion to achieve complete solder reflow, avoiding thermal and/or mechanical

damage to component, board, adjacent components.

- Trigger the vacuum to remove the solder that connects the lead and barrel.
- Repeat for all leads until the component can be removed.
- Inspect barrel(s) and land(s) for damage.

1.8.14.1.3 Component Removal Using Solder Fountain Method

- Pre/auxiliary heat assembly and/or component, if required.
- Reflow all joints in solder fountain.
- Remove old component and either immediately replace with new component, or clear through-holes for component replacement later.

Note: Copper dissolution is a concern when using a solder fountain and can be impacted by dwell time, temperature and alloy in use.

1.8.14.2 Component Installation

1.8.14.2.1 Land Preparation Land/pad/site preparation (including the barrel of a Plated Through-Hole [PTH]) needs to be performed prior to either the installation or replacement of a new component. It is critical to avoid both thermal and/or mechanical damage to the land and substrate during these preparation steps. Land preparation includes:

- *Remove Old Solder* – This is typically performed using a soldering iron and solder wick (a desoldering braid via capillary action), or with a continuous vacuum desoldering technique employing a solder extractor and tip which allows reflow and removal of the old solder to occur simultaneously. This is important in both through hole as well as SMT technology. A clear PTH barrel and flat, co-planar SMT pads are needed to easily and successfully install a replacement component once site preparation is complete.
- *Clean Lands* – Old flux residues leftover from the removal of the component being replaced and/or after the removal of any residual solder are cleaned in this step prior to adding any new solder or beginning the installation process of the replacement component.

1.8.14.2.2 Surface Mount Components

- When applicable, prefill the lands/pads with solder using either solder preforms, solder wire or solder paste. Whether to prefill the individual SMT pads with solder or not is typically dictated by the type of part being replaced as well as the method being used to perform the replacement.
- Align and place component on its lands/pads (tack, if necessary). The need to tack solder is typically dictated by the component type and the installation method.

- When applicable, apply the solder paste to lead/land area if not applied prior to component placement. The use of solder paste is typically driven by the type of component being installed and the method being used for the installation. If solder paste application post component installation is the method of choice, typically the solder paste is dispensed via a syringe.
- Preheat and/or auxiliary heat the assembly and/or component, if required. Factors such as the thermal mass of the component/assembly and whether or not the component is grounded (case soldered) to the PCB all contribute to the amount of heat to be applied and maintained to successfully install and solder the SMT component. The component's thermal sensitivity is also an important factor. Convection ovens, hot plates, IR preheaters and benchtop air-bath preheaters are often used to apply heat.
- When applicable, predry the applied solder paste. This is typically done to activate the flux within the solder paste to remove oxides/promote proper wetting, and also to drive off solvents to limit internal voiding during solder joint formation. Considerations such as the solder paste supplier's recommendations, the condition or state of the assembly (conformally coated or not, temperature sensitivity of the balance of the assembly...) all need to be considered (as should be done on the balance of these steps) before performing this task.
- Reflow the component's solder joints (individually, in groups or all together) with concentrated "targeted" heat in a rapid, controllable manner while maintaining lead/land alignment. Joints should remain at an appropriate temperature (above the melting point of solder alloy) for a sufficient time to achieve optimal intermetallic solder joint formation. Time and temperature may vary based on the reflow technique being used (Conduction, e.g., a soldering iron vs. Convection, e.g., a hot air pencil) and the type of component being installed (hidden, non-hidden solder joints, with or without a thermal plane, leaded, non-leaded...).
- Avoid thermal and/or mechanical damage to the component, PCB, adjacent components and their solder joints. Consistently accomplishing this requires a skilled operator as well as taking the time for proper site preparation prior to performing the task, e.g., masking to shield surrounding areas, preheating, and proper tool selection (soldering iron tip size, shape, tip temperature, or nozzle size, shape and temperature for hot air applications), all where applicable.
- Clean and inspect. Inspection verifies proper alignment and orientation of the replaced component, acceptable solder joints for that same component, as well as cleanliness and no signs of thermal/mechanical damage at the "reworked/repared/modified site" as well as the immediate surrounding area (collateral damage).

1.8.14.2.3 Through-Hole Components

- Form component leads as required.
- Insert a component into the PCB.
- Preheat and/or auxiliary heat the assembly and/or component if required. Factors such as the thermal mass of the component/assembly and how the component's individual PTHs are connected to internal ground layers within the PCB all contribute to amount of heat to be applied and maintained to successfully install and solder the through-hole component. Convection ovens, hot plates, IR preheaters and benchtop air-bath preheaters are often used to apply heat. Considerations such as the condition or state of the assembly (conformally coated or not, temperature sensitivity of the balance of the assembly...) need to be carefully evaluated (as should be done on the balance of these steps) before performing this task.
- Reflow the component's solder joints (individually, in groups or all together) with concentrated "targeted" heat in a rapid, controllable manner while remaining at an appropriate temperature (above the melting point of solder alloy) for a sufficient time to achieve optimal intermetallic solder joint formation. Time and temperature may vary based on the reflow technique being used (Conduction, e.g., a soldering iron vs. Convection, e.g., a hot air gun) and the type of component being installed (a few leads, many leads, easily accessible leads...).
- Avoid thermal and/or mechanical damage to the component, PCB, adjacent components and their solder joints. Consistently accomplishing this requires a skilled operator as well as taking the time for proper site preparation prior to performing the task e.g., masking to shield surrounding areas, preheating, and proper tool selection (soldering iron tip size, shape, tip temperature, or nozzle size, shape and temperature for hot air applications), all where applicable.
- Clean and inspect. Inspection verifies proper alignment and orientation of the replaced component, acceptable solder joints for that same component, as well as cleanliness and no signs of thermal/mechanical damage at the "reworked/repared/modified site" as well as the immediate surrounding area (collateral damage).

1.8.15 Cleaning Station/System Regardless of the Class of Product serviced, a cleaning system that is "chemically compatible" to the flux system(s) in use will be essential to a satisfactory repair. In organizations that perform procedures on Class 3 Products, it may also be necessary to have a cleanliness test system in order to periodically evaluate the ability of the cleaning system to meet the requirements/expectations of the user. Interim or in-process cleaning at the workstation should be used pending completion of the procedure and the final cleaning. Common Procedure 2.2 in this document is an example of an interim cleaning process.

that could be used assuming the product in question is compatible with this procedure.

1.8.16 Component Removal and Installation The variety of large and small components require an array of specialty use tools and methods for safe, efficient component removal. These tools generally use conductive heating (by contact), convective heating (by hot gas) or infrared heating (by focused infrared lamps) to provide the required heat to the areas being reworked/repared or modified.

1.8.17 Conformal Coating Area The removal and re-application of conformal coating may use specialized processing, safety, and utility requirements, as well as equipment for automation, air/gas supply, vacuum pressure, venting/exhaust, humidity controls, UV illuminations, fire suppression, waste disposal, etc. The extent and cost of these measures may be controlled with implementation of a single central conformal coating area for compatible materials. The various methods for coating removal (chemical/solvent, abrasion, peeling, thermal, grinding, scraping, micro blasting) are often dictated by the type of coating applied (reference sections 2.3.1-2.3.6 of this document). Re-application, touch up and rework are typically done manually, utilizing many of the same equipment/chemical requirements as the original application. Section 10 of IPC-HDBK-830 (Guidelines for Design, Selection and Application of Conformal Coatings) titled "Rework, Repair And Restoration" offers additional information in regards to the removal and re-application of coating for many types of Conformal Coat, and should be considered as a resource here.

1.8.18 Selecting a Process Selecting the process used for the rework/repair/modification action depends on a variety of factors in addition to the cost of tools and training. Every process and its associated equipment have advantages and precautions in a particular component installation or removal situation. These include:

- Type of component
 - lead (termination) type
 - body composition
- Size of component
- Moisture sensitivity level of component
- Type of substrate (FR-4, ceramic, etc.)
- Component mounting site
 - thermal mass considerations
 - adjacent components
 - accessibility of component or joints
- Whether the component is being installed or removed
- Whether the component being removed must be salvaged
- Applicable workmanship specifications
- EOS/ESD control requirements

1.8.19 Time Temperature Profile (TTP) To ensure acceptable results of the rework procedure, it is critical to establish a time temperature profile for the process.

Note: The time temperature profile is dependent, in part, on ambient relative humidity. Relative humidity variations of greater $\pm 15\%$ from those prevailing when the TTP was established may require modification of the procedure defined during TTP.

The following things should be considered in order to achieve an acceptable TTP:

- Select a preheat temperature for both the component and the Assembly. (The components, whether ceramic or plastic, need to be preheated, as does the assembly.)

Note: If plastic body or tape bodied components are used, see IPC J-STD-033 *Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices* for information on handling of moisture sensitive components.

- Solder paste characteristics must be identified including viscosity, thixotropy, rheology, deposition thickness and drying time/temperature; or if using flux cored solder wire, land prefill solder quantity and prefill coplanarity requirements.
- Define a cleaning procedure which will meet the end item cleanliness requirements of the customer.
- Confirm through destructive physical examination and/or X-ray analysis that the process defined will yield a BGA attachment which meets any quality requirements imposed.
- Define, if used, an accelerated cooling system which does not exceed the thermal gradient limits of the most sensitive component of the assembly.

For additional information, see IPC-7095 and IPC-AJ-820.

1.9 Lead Free With the implementation by European Union Waste Electrical and Electronic Equipment Directive (WEEE) and Restriction of Hazardous Substances Directive (RoHS), the use of lead-free (Pb-free) solder is becoming more common in non-aerospace applications. Additionally, the rework of PCBs assembled with lead-free solder is similar to tin-lead solder, e.g., Sn63, Sn60, etc., with some considerations and cautions. The procedures in this document are not specific to any solder alloy type and should be compatible with commonly used tin-lead and lead-free solders. See Section 1.8.13.1.

It is very important for compliance to RoHS and WEEE that a tin-lead solder is not mistakenly introduced during rework to a PCB assembled with lead-free solder. Thus it is generally a good practice to segregate soldering iron tips between those used with lead-free and tin-lead solder.

Lead-free solders in use today include common alloys available from many suppliers e.g., 300344, 100344, 100345, 100346, 100347, 100348, 100349, 100350, 100351, 100352, 100353, 100354, 100355, 100356, 100357, 100358, 100359, 100360, 100361, 100362, 100363, 100364, 100365, 100366, 100367, 100368, 100369, 100370, 100371, 100372, 100373, 100374, 100375, 100376, 100377, 100378, 100379, 100380, 100381, 100382, 100383, 100384, 100385, 100386, 100387, 100388, 100389, 100390, 100391, 100392, 100393, 100394, 100395, 100396, 100397, 100398, 100399, 100400, 100401, 100402, 100403, 100404, 100405, 100406, 100407, 100408, 100409, 100410, 100411, 100412, 100413, 100414, 100415, 100416, 100417, 100418, 100419, 100420, 100421, 100422, 100423, 100424, 100425, 100426, 100427, 100428, 100429, 100430, 100431, 100432, 100433, 100434, 100435, 100436, 100437, 100438, 100439, 100440, 100441, 100442, 100443, 100444, 100445, 100446, 100447, 100448, 100449, 100450, 100451, 100452, 100453, 100454, 100455, 100456, 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and SnCu0.7, as well as engineered alloys that are developed by individual suppliers. Generally, lead-free solder alloys with tin, silver, and/or copper have a higher liquidus (or melting) temperature than traditional tin-lead solder alloys. The regular lead-free solder alloys with a higher liquidus temperature will generally have the following differences over tin-lead solder alloys:

- Solderability indicators such as wetting angles, joint appearance, etc. will be different. See IPC-A-610 for more detailed information.
- Different flux and special cleaning processes.
- Longer dwell times.
- Wetting times may be extended.
- Higher temperature and longer dwell times will increase oxidation, thus the use of inert atmosphere (such as nitrogen) should be considered to mitigate oxidation issues.

There are “low temperature” lead-free solder alloys, e.g., Sn42Bi58 plus engineered lead-free solder alloys alternatives. In general, regular and low temperature lead-free solders should not be mixed for rework of PCB assemblies. Ideally, the original solder alloy used for the initial assembly process is reused for the rework process, but at a minimum, it is important to ensure the original solder alloy and the solder alloy used for the rework are compatible.



7711/7721

Rework, Modification and
Repair of Electronic Assemblies

Number: **2.1**

Date: 1/17

Handling Electronic Assemblies

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

ESD is the rapid flow of electricity between objects with different potential.

When the electrical energy is allowed to come in contact with or even close to a sensitive component it can cause damage to the component. Electrostatic-Discharge Sensitive (ESDS) components are those components that are affected by these high energy surges. The relative sensitivity of a component to ESD is dependent upon its construction and materials. As components become smaller and operate faster, the sensitivity increases.

Electrical Overstress (EOS) is the internal result of a unwanted application of electrical energy that results in damaged components. This damage can be from many different sources, such as electrically powered process equipment or ESD occurring during handling or processing.

ESDS components can fail to operate or change in value as a result of improper handling or processing. These failures can be immediate or latent. The result of immediate failure can be additional testing and rework or scrap. However the consequences of latent failure are the most serious. Even though the product may have passed inspection and functional test, it may fail after it has been delivered to the customer.

It's important to build protection for ESDS components into circuit designs and packaging. However, in the manufacturing and assembly areas, we often work with unprotected electronic assemblies that are attached to the ESDS components. This section will be dedicated to safe handling of these unprotected electronic assemblies.

For that purpose, the following subjects are addressed:

- 2.1.1 Electrical Overstress (EOS) Damage Prevention
- 2.1.2 Electrostatic Discharge (ESD) Damage Prevention
- 2.1.3 Physical Handling

Information in this specification is intended to be general in nature. Additional detailed information can be found in EIA-625, Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices, or ANSI/ESD-S20.20 ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices).

2.1.1 Electrical Overstress (EOS) Damage Prevention

Electrical components can be damaged by unwanted electrical energy from many different sources. This unwanted electrical energy can be the result of ESD potentials or the result of electrical spikes caused by the tools we work with, such as soldering irons, soldering extractors, testing instruments or other electrically operated process equipment. Some devices are more sensitive than others. The degree of sensitivity is a function of the design of the device. Generally speaking higher speed and smaller devices are more susceptible than their slower, larger predecessors. The purpose or family of the device also plays an important part in component sensitivity. This is because the design of the component can allow it to react to smaller electrical sources or wider frequency ranges. EOS has become a serious problem and will be more critical in the future.

When considering the susceptibility of the product it is important to keep in mind the susceptibility of the most sensitive component in the assembly. Applied unwanted electrical energy can be processed or conducted just as an applied signal would be during circuit performance.

Before handling or processing sensitive components, tools and equipment need to be carefully tested to ensure that they do not generate damaging energy, including spike voltages. Current research indicates that voltages and spikes less than 0.5 volt are acceptable. However, an increasing number of extremely sensitive components require that soldering irons, solder extractors, test instruments and other equipment do not generate spikes greater than 0.3 volt.

As required by most ESD specifications such as EIA-625 or ESDA 20.20, periodic testing may be warranted to preclude damage as equipment performance may degrade with use over time. Maintenance programs are also necessary for

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Documents

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Number: **2.1**Subject: **Handling Electronic Assemblies**Date: **1/17**

process equipment to ensure the continued ability to not cause EOS damage.

2.1.2 Electrostatic Discharge (ESD) Damage Prevention

The best ESD damage prevention is a combination of preventing static charges and eliminating static charges if they do occur. All ESD protection techniques and products address one or both of the two issues.

ESD damage is the result of electrical energy that was generated from static sources either being applied or in close proximity to ESDS devices. Static sources are all around us. The degree of static generated is relative to the characteristics of the source. To generate energy relative motion is required. This could be contacting, separation, or rubbing of the material.

Most of the serious offenders are insulators since they concentrate energy where it was generated or applied rather than allowing it to spread across the surface of the material. Common materials such as plastic bags or Styrofoam containers are serious static generators and as such are not to be allowed in processing areas especially static safe areas. Peeling adhesive tape from a roll can generate 20,000 volts. Even compressed air nozzles which move air over insulating surfaces generate charges.

Destructive static charges are often induced on nearby conductors, such as human skin, and discharged into conductors. This can happen when a printed board assembly is touched by a person having a static charge potential. The electronic assembly can be damaged as the discharge passes through the conductive pattern to a static sensitive component. Static discharges may be too low to be felt by humans (less than 3500 volts), and still damage ESDS components. Typical static voltage generation is included in Table 2.

2.1.3 Physical Handling

Care must be taken during acceptability inspections to ensure product integrity at all times. Table 3 provides general guidance.

Physical Damage

Improper handling can readily damage components and assemblies (e.g., cracked, chipped or broken components and connectors, bent or broken terminals, badly scratched board surfaces and conductor lands). Physical damage of this type can ruin the entire assembly or attached components.

Table 1 Typical Static Charge Sources

Work surfaces	Waxed, painted or varnished surfaces Untreated vinyl and plastics Glass
Floors	Sealed concrete Waxed or finished wood Floor tile and carpeting
Clothes and personnel	Non-ESD smocks Synthetic materials Non-ESD Shoes Hair
Chairs	Finished wood Vinyl Fiberglass Non-conductive wheels
Packaging and handling materials	Plastic bags, wraps, envelopes Bubble wrap, foam Styrofoam Non-ESD totes, trays, boxes, parts bins
Assembly tools and materials	Pressure sprays Compressed air Synthetic brushes Heat guns, blowers Copiers, printers

Table 2 Typical Static Voltage Generation

Source	10-20% humidity	65-90% humidity
Walking on carpet	35,000 volts	1,500 volts
Walking on vinyl flooring	12,000 volts	250 volts
Worker at a bench	6,000 volts	100 volts
Vinyl envelopes (Work Instructions)	7,000 volts	600 volts
Plastic bag picked up from the bench	20,000 volts	1,200 volts
Work chair with foam pad	18,000 volts	1,500 volts

IPC-7711/7721	
Number: 2.1	Subject: Handling Electronic Assemblies
Date: 1/17	

Table 3 General Rules for Handling Electronic Assemblies

1. Keep work stations clean and neat. There must not be any eating, drinking, or use of tobacco products in the work area.
2. Minimize the handling of electronic assemblies and components to prevent damage.
3. When gloves are used, they need to be changed as frequently as necessary to prevent contamination from dirty gloves.
4. Solderable surfaces are not to be handled with bare hands or fingers. Body oils and salts reduce solderability, promote corrosion and dendritic growth. They can also cause poor adhesion of subsequent coatings or encapsulates.
5. Do not use hand creams or lotions containing silicone since they can cause solderability and conformal coating adhesion problems..
6. Never stack electronic assemblies or physical damage may occur. Special racks need to be provided in assembly areas for temporary storage.
7. Always assume the items are ESDS even if they are not marked.
8. Personnel need to be trained and follow appropriate ESD practices and procedures, including use of wrist or heel straps.
9. Never transport ESDS devices unless proper packaging is applied.

Contamination

Contamination by handling with bare hands or fingers without some form of protection causes soldering and coating problems; body salts and oils, and unauthorized hand creams are typical contaminants. Body oils and acids reduce solderability, promote corrosion and dendritic growth. They can also cause poor adhesion of subsequent coatings or encapsulates. Lotion formulated specifically for use in solder assembly areas is available. Normal cleaning procedures will not always remove such contaminants. The best solution is to prevent contamination.

When assemblies are removed from their protective wrappings, handle with great care. Touch only the edges away from any edge connector tabs. Where a firm grip on the assembly is required, gloves meeting EOS/ESD requirements need to be worn. These principles are especially critical when no-clean processes are employed.

Handling Electronic Assemblies

If no ESDS markings are on an assembly, it still needs to be handled as if it were an ESDS assembly. However, ESDS components and electronic assemblies need to be identified by suitable EOS/ESD labels. Many sensitive assemblies will also be marked on the assembly itself, usually on an edge connector. To prevent ESD and EOS damage to sensitive components, all handling, unpacking, assembly and testing must be performed at a static controlled work station.

Avoid contaminating solderable surfaces prior to soldering. Whatever comes in contact with these surfaces must be clean. When boards are removed from their protective wrappings, handle them with great care. Touch only the edges away from any edge connector tabs. Where a firm grip on the board is required due to any mechanical assembly procedure, gloves meeting EOS/ESD requirements need to be worn. These principles are especially critical when no-clean processes are employed.

Handling After Solder

After soldering and cleaning operations, the handling of electronic assemblies still requires great care. Finger prints are extremely hard to remove and will often show up in conformally coated boards after humidity or environmental testing. Gloves or other protective handling devices need to be used to prevent such contamination. Use mechanical racking or baskets with full ESD protection when handling during cleaning operations. ESD events can occur when sensitive devices/assemblies are placed on any nonconductive surface, regardless of whether or not a wrist or shoe strap is used.

Common Tools and Equipment

Work environments require tools and equipment to conduct electronic assembly operations. The following information is provided as guidance regarding the use of common equipment. EIA-625 and ESDA 20.20 provide more specific information.

Number: **2.1**Subject: **Handling Electronic Assemblies**Date: **1/17****NOTES**



7711/7721

Rework, Modification and
Repair of Electronic Assemblies

Date: 1/17

Number: 2.2

Cleaning

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

Surface contaminants can significantly affect soldering, bonding, coating and the electrical characteristics of printed board and assemblies. This procedure outlines the cleaning methods for printed circuit boards and assemblies.

BACKGROUND

In the past few years, the Environmental Protection Agency (EPA) has been actively involved in reducing the production of chlorofluorocarbons (CFC's). Through their efforts, and the Montreal Protocol, the production of CFC's have been frozen to 1986 levels with requirements to further decrease to zero production by the year 2000. The London Amendments (June 1990) to the protocol are even more restrictive.

Cleaning of the PCB is an important part of any rework/repair process. The different cleaning processes are dependent upon the type of flux used in the soldering process or the type of contaminate to be removed. A general rule of thumb is "like dissolves like," which is a quick way of saying that usually organic/nonpolar contaminants are best removed by nonpolar solvents and inorganic/polar contaminants are best removed by polar solvents.

A desirable cleaning medium should:

- A. Not be harmful to employees or the environment.
- B. Possess excellent wetting ability.
- C. Dissolve and removes both soluble and particulate contaminants.
- D. Be compatible with the PCB assembly.
- E. Be stable during use.

INTRODUCTION

If rework/repair operations are performed in a facility that has an automated cleaning system (i.e., batch, in-line, aqueous, semi aqueous, or solvent), then such equipment should be used to clean the assembly.

If an automated system is not available, the cleaning method that follows should be used to reduce surface contamination

prior to using adhesives, coating materials or soldering. A cleaning step after soldering is used to ensure that surface contaminants are not trapped beneath conformal coatings or encapsulants, nor will they contribute to future functional assembly problems.

LIMITATIONS

1. The ability of solvent based cleaning solutions to remove flux residue containing polyglycols should be assessed since not all solvent based cleaning solutions will remove polyglycols.
2. A de-ionized (DI) water rinse should follow IPA/DI cleaning except that a water rinse for double sided printed circuit boards with plated through holes may not be required.
3. Potable (drinking) water should not be used as a final rinse due to the potential of contaminating the printed circuit board assembly with chlorine, fluorine and halides.
4. When automated cleaning is used for assemblies that have been conformally coated, it is important that the cleaning process is compatible with the type of coating used and with any unsealed components. The coating should be checked to ensure that the coating will not be degraded by the cleaning process.

TOOLS AND MATERIALS

Black Light	De-ionized Water (DI)
Brush, Soft Bristles	Gloves
Cleaner, Aqueous or Semi-Aqueous	Isopropyl Alcohol (IPA)
Containers	Oven
	Wipes, Lint Free

PROCEDURE

CAUTION

Use clean gloves during this entire operation.

NOTE

To reduce solvent volumes, mixtures of IPA with water and IPA with solvent are available in pressurized containers. The propellants are HFC's. These containers may be fitted with a bristle brush spray attachments for additional cleaning action.

1. Clean the board in an Aqueous or Semi-Aqueous cleaner, or pour approximately 10 ml of cleaning solution per 26 square centimeters of affected area.

Number: **2.2**Subject: **Cleaning**Date: **1/17**

2. Scrub the board vigorously with a continually wet soft bristle brush for 10 seconds.
3. Rinse the area with 10 ml per 26 square centimeters of clean Isopropyl Alcohol to effectively remove all potentially harmful residues.
4. Handle the board by the edges and blot the excess Isopropyl Alcohol with clean, lint free cloth.
5. Examine board visually for cleanliness. The use of a black light will help detect contaminants that will fluoresce.
6. Dry boards in oven, if desired.
7. If the boards or assemblies are to be stored before use or coating, remove them from the oven and allow to cool until they can be handled. Place the boards or assemblies into self sealing bags with packages of desiccant.

INSPECTION GUIDANCE

1. Flux residue
2. Particulate matter
3. Chlorides, carbonates and white residues
4. Surface appearance

NOTES



7711/7721

Rework, Modification and
Repair of Electronic Assemblies

Date: 1/17

Number: **2.3.1**

Coating Removal, Identification of Conformal Coating

Board Type: R, F, W, C
See 1.4.2
Skill Level: Advanced
See 1.4.3
Level of Conformance: High
See 1.5.1

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

This procedure covers the techniques for identifying various coatings so that the appropriate coating removal method can be selected.

Conformal Coating Types IPC-CC-830 has superseded MIL-I-46058 as the primary specification for printed circuit assembly conformal coatings, and covers the following types of conformal coatings:

1. Type AR – Acrylic resin (includes lacquers and varnishes)
2. Type ER – Epoxy resin
3. Type SR – Silicone resin
4. Type UR – Polyurethane resin
5. Type XY – Paraxylylene

REFERENCES

- 2.1 Handling Electronic Assemblies
- 2.2 Cleaning
- 2.5 Baking and Preheating
- 2.6 Epoxy Mixing and Handling
- IPC - CC-830

TOOLS AND MATERIALS

Abrasive Discs	Heated Blade
Brush	Knife
Cleaner	Solvent
Cleaner Wipes	Thermal Parting Tool
Cotton Swab	Wood Stick
Dental Style Drill	

PROCEDURE

To determine the appropriate coating removal procedure the coating must first be identified. During original manufacture the specific coating is usually known. Consequently, the coating removal methods can usually be specified and based on the

known coatings being used. Labels conforming to Standards such as IPC-1066 (superseded by IPC/JEDEC J-STD-609) and IPC/JEDEC J-STD-609 may be present on the assembly to identify the coating material.

When identification of the coating is not available, simple observation and testing will help identify the coating characteristics so that the proper removal procedure can be specified.

NOTE

The generic or commercial identification of the coating material is not necessary to accomplish coating removal.

1. Hardness

Penetration test in a non-critical area to determine relative hardness. The harder the coating the more suitable to pure abrasive techniques. The softer and gummier the coatings the more suitable to the brushing removal procedures.

2. Transparency

Obviously transparent coatings are usually more suitable for removal than the opaque type. Removal methods used with opaque coatings must be far more controllable and less sensitive to damaging the covered components and printed board surfaces and are usually slower.

3. Solubility

Most coatings are soluble; however, the solvent required to dissolve a specific coating may also attack the board and/or components. Unless directed by other maintenance actions, the solubility test and solvent used should be limited to isopropyl alcohol. Test coat the surface in a noncritical area by brushing on a small quantity and observing the solubility action.

CAUTION

Printed board assemblies should not be immersed in harsh solvents.

4. Thermal Removal

Use a thermal parting device with controlled heating and without a cutting edge to determine whether the coating can be thermally removed. Start with a low temperature, approximately 100°C, and increase the temperature until the coating is removed. If the coating flows or gums up,

Number: **2.3.1**Subject: **Coating Removal, Identification of Conformal Coating**Date: **1/17**

the temperature is too hot or the coating is not suitable for thermal removal.

5. *Stripability*

Carefully slit the coating with a sharp blade in a non-critical area and try to peel back from the surface to determine if this method is feasible. Due to the adhesion required of coating materials, stripable techniques without chemical aids is usually very limited.

6. *Thickness*

Coating thickness is determined by visual inspection. Thin coatings show sharp outlines of the components and almost no fillet at intersection points of part leads to the circuit board. Thick coatings reduce these sharp outlines and show fillets where part leads intersect with the board. Coatings thinner than 0.064 cm [0.025 in] are considered thin. Coatings thicker than 0.064 cm [0.025 in] are classed as thick.

The specific coating to be removed may have one or more of these characteristics and consequently the removal method selected should consider the composite characteristics.

See Figure 1 for Conformal Coating Identification.

See Table 1 for Conformal Coating Characteristics.

See Table 2 for Conformal Coating Removal Methods.

INSPECTION GUIDANCE

1. Visual examination or UV light may be used to verify removal of coating.
2. Visually inspect PCA for damage from removal of conformal coating.

NOTES

IPC-7711/7721	
Number: 2.3.1	Subject: Coating Removal, Identification of Conformal Coating
Date: 1/17	

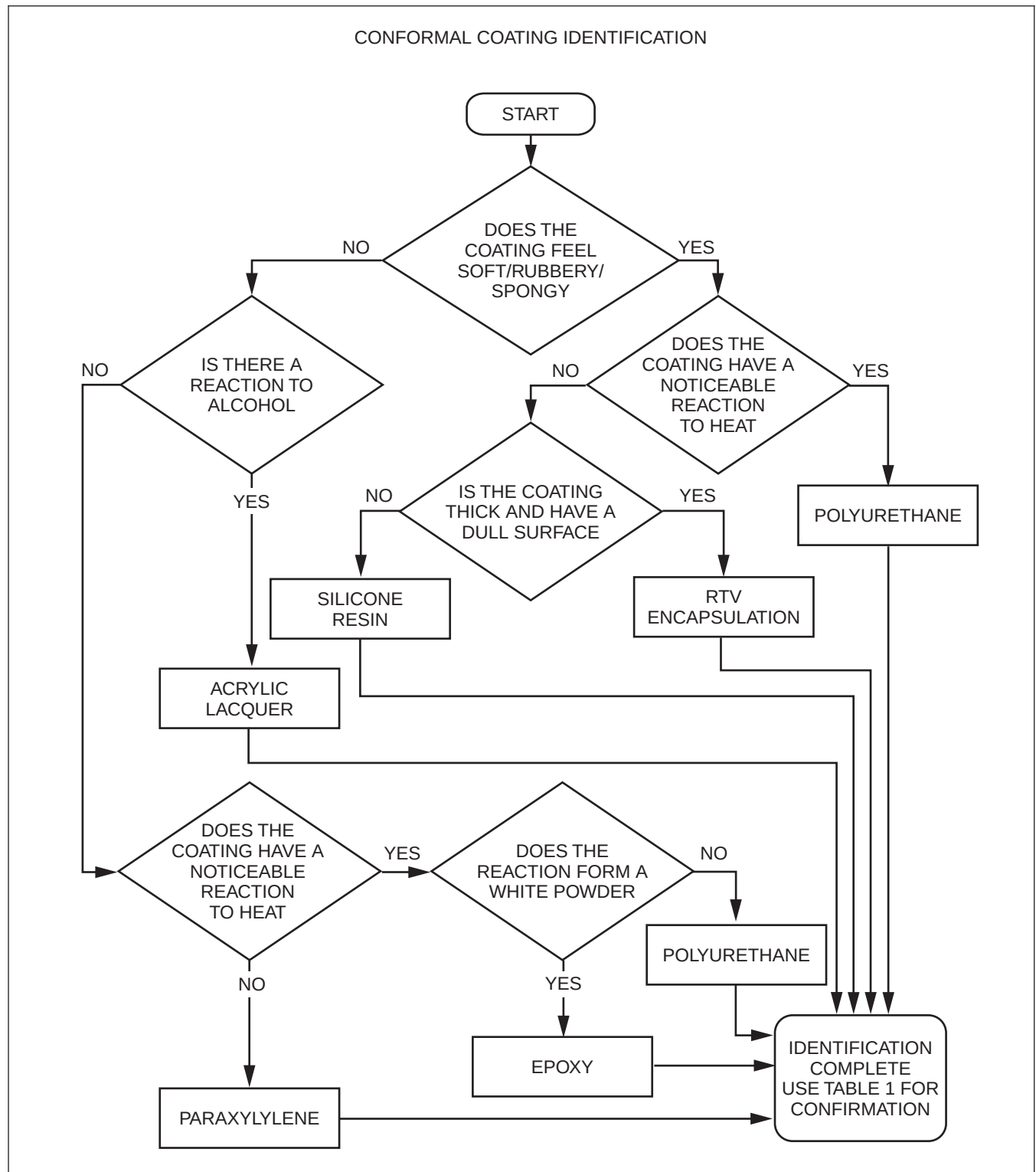


Figure 1 Conformal Coating Identification

Number: **2.3.1**Subject: **Coating Removal, Identification of Conformal Coating**Date: **1/17****Table 1 Conformal Coating Characteristics**

Characteristics	Conformal Coating Type				
	Epoxy	Acrylic	Poly-urethane	Silicone Resin	Paraxylylene
Hard	✓		✓		✓
Medium Hard		✓	✓		
Soft			✓	✓	
Heat Reaction	✓	✓	✓		
Surface Bond - Very Strong	✓			✓	✓
Surface Bond - Strong		✓		✓	
Surface Bond - Medium			✓	✓	
Surface Bond - Light				✓	
Solvent Reaction		✓			
Non-porous Surface	✓	✓	✓		✓
Glossy Surface	✓	✓	✓		
Semi-glossy Surface	✓			✓	
Dull Surface					✓
Rubbery Surface				✓	
Brittle	✓	✓			
Chips	✓	✓			
Peels and Flakes		✓	✓		✓
Stretches			✓	✓	
Scratch, Dent, Bend, Tear			✓	✓	✓

Table 2 Conformal Coating Removal Methods

Conformal Coating	Removal Method				
	2.3.2 Solvent Method	2.3.3 Peeling Method	2.3.4 Thermal Method	2.3.5 Grinding Scraping Method	2.3.6 Micro Blasting Method
Paraxylylene			1	2	3
Epoxy			1	2	3
Acrylic	1		2	3	4
Polyurethane	3		1	2	4
Silicone Thin	1		2	3	4
Silicone Thick		1		2	

NOTE: The preferred order for applying removal methods to specific coatings is numerically indicated. These removal methods are listed in ascending order. More than one method may be required.



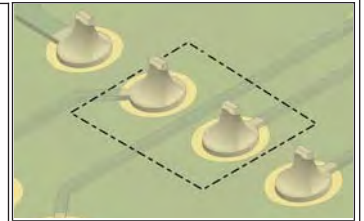
7711/7721

Rework,
Modification
and Repair of
Electronic Assemblies

Number: **2.3.2**

Date: **1/17**

Coating Removal, Solvent Method



Board Type: R, F, W, C
See 1.4.2

Skill Level: Advanced
See 1.4.3

Level of Conformance: High
See 1.5.1

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

This procedure uses a solvent to remove surface coatings. This procedure can be used for spot or overall coating removal of conformal coatings or solder resists.

Approved solvents may be used to remove specific soluble type coatings on a spot basis by brushing or swabbing the local area with the controlled application of solvent until the area is free of the coating material.

If warranted, all the soluble type coating can be removed by immersing and brushing the entire printed board or printed board assembly.

To determine the appropriate coating removal procedure the coating must first be identified. Refer to procedure number 2.3.1.

NOTE

Coating removal may require the use of one or more methods.

CAUTION

Determine, on a module by module basis, the hazards to parts, etc., by short term immersion in the removal solvents. If chloride based or other harsh solvents are used, extreme care must be exercised to prevent damage to base material, component parts, plated-through holes, and solder joints. Some solvent coating removal methods can cause expansion or swelling of the base material which can degrade the printed board or printed board assembly. Under no circumstances should these solvents be used except in a closely controlled process. It is recommended that the printed board or printed board assembly be inspected to ensure that no damage has occurred.

Before using any solvent refer to Material Safety Data Sheets.

REFERENCES

- 2.1 Handling Electronic Assemblies
- 2.2 Cleaning
- 2.3.1 Coating Removal, Identification of Conformal Coatings
- 2.4.1 Coating Replacement, Solder Resist
- 2.4.2 Coating Replacement, Conformal Coatings/Encapsulants

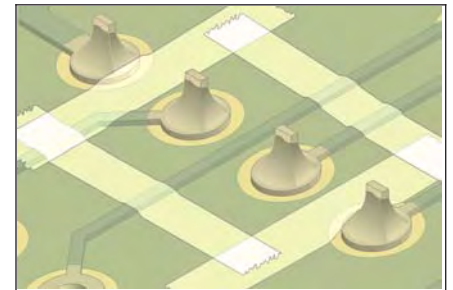


Figure 1 Apply tape to outline for coating removal.



Figure 2 Apply solvent with foam swab to remove coating.

Number: **2.3.2**Subject: **Coating Removal, Solvent Method**Date: **1/17****TOOLS AND MATERIALS**

Brush	Suitable Solvent
Cotton Swab	Thermal Parting Tool
Polyimide Tape	Wood Stick
Knife	

PROCEDURE – LOCAL SPOT REMOVAL

1. Apply Polyimide tape to outline the area where the coating needs to be removed. (See Figure 1.)
2. Dip the end of a foam swab in stripping solution and apply a small amount to the area of coating to be removed. (See Figure 2.)

As an alternative, a small cotton patch can be cut to the size of the area masked (see Figure 1), saturated with the stripping solution, and pressed into intimate contact with the surface of the coating to be removed. The patch will retard the evaporation of certain solvents and reduce exposure time.

NOTE

Since various substances may be used as coatings, the time required for a given coating to dissolve or soften will vary. Reapply solvent several times as most solvents evaporate rapidly.

3. Rub the treated surface carefully with a brush or wood stick to dislodge the coating. A wedge shaped applicator tip, knife, or heated blade may be effective in removing some coatings, particularly polyurethanes.
4. Neutralize or clean the stripped area and dry.

PROCEDURE – OVERALL REMOVAL

1. A single step for removal of all the coating may be completed by providing a continuous flow of solvent. Alternately, process the board in a series of tanks containing mild solvent, starting with a high contamination tank and progressing sequentially to a final, fresh solvent tank.
2. Neutralize or clean the stripped area and dry.

INSPECTION GUIDANCE

1. Visual examination or UV light may be used to verify complete removal of coating.
2. Visually inspect PCA for damage from removal of conformal coating.

NOTES

Coating Removal Required at Outlined Areas



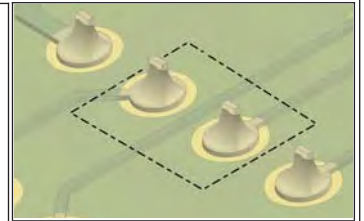
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Rework,
Modification
and Repair of
Electronic Assemblies

Number: **2.3.3**

Date: 1/17

Coating Removal, Peeling Method



Board Type: R, F, W, C
See 1.4.2
Skill Level: Advanced
See 1.4.3
Level of Conformance: High
See 1.5.1

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

This peeling removal method for coating can be used only under special circumstances. Normally this method is used to remove RTV silicone or other thick rubbery-like coating materials.

The coating material is removed using a dull knife or otherwise dull blade to slit the coating material and to peel it off the printed board or printed board assembly.

To determine the appropriate coating removal procedure the coating must first be identified. Refer to procedure number 2.3.1.

NOTE

This method is limited to coatings that are rubbery in nature to allow the coating material to be slit into small sections and peeled off the printed board assembly.

REFERENCES

- 2.1 Handling Electronic Assemblies
- 2.2 Cleaning
- 2.3.1 Coating Removal, Identification of Conformal Coatings
- 2.4.1 Coating Replacement, Solder Resist
- 2.4.2 Coating Replacement, Conformal Coatings/Encapsulants

TOOLS AND MATERIALS

Heated Blade
Knife
Wood Sticks

PROCEDURE

1. Slit and peel off the coating material with a dull knife or heated dull blade. (See Figure 1.)
2. Repeat as needed until the required material is removed.

INSPECTION GUIDANCE%

1. Visual examination or UV light may be used to verify complete removal of coating.
2. Visually inspect PWA for damage from removal of conformal coating.

NOTE

Coating Removal Required at Outlined Area

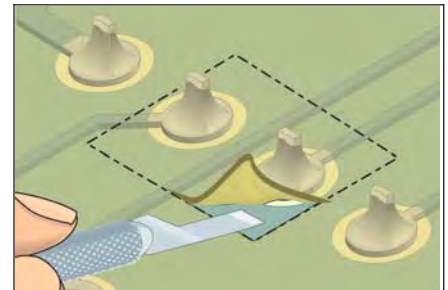


Figure 1 Slit and peel off coating using a knife or heated blade.

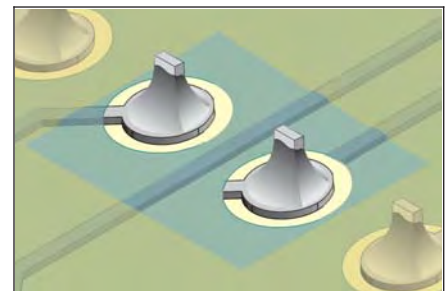


Figure 2 Removal complete.

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Number: **2.3.3**Subject: **Coating Removal, Peeling Method**Date: **1/17****NOTES**



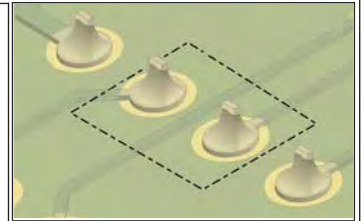
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Rework,
Modification
and Repair of
Electronic Assemblies

Date: 1/17

Number: 2.3.4

Coating Removal, Thermal Method



Board Type: R, F, W, C
See 1.4.2
Skill Level: Advanced
See 1.4.3
Level of Conformance: High
See 1.5.1

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

This coating removal procedure uses a controlled, low temperature, localized heating method for removing thick coatings by an overcuring or softening means.

Two methods are covered. The first method uses various shaped, temperature controlled tips, with dull edges to soften and remove the coating.

The second method uses a localized controlled jet of hot air or inert gas to soften the coating material which is pushed away or removed by a non-marring tool.

These methods do not burn or char either the coating or printed board.

CAUTION

Soldering irons should not be used for coating removal as their high operating temperatures will cause the coatings to char and possibly delaminate the printed board base material.

The use of thinned down soldering iron tips or soldering iron heated thin cutting blades are not recommended since they do not provide controlled heating and may present dangerous sharp edges to the workpiece surface.

To determine the appropriate coating removal procedure the coating must first be identified. Refer to procedure number 2.3.1.

REFERENCES

- 2.1 Handling Electronic Assemblies
- 2.2 Cleaning
- 2.3.1 Coating Removal, Identification of Coatings
- 2.4.1 Coating Replacement, Solder Resist
- 2.4.2 Coating Replacement, Conformal Coatings/Encapsulants

TOOLS AND MATERIALS

Brush	Knife
Heated Blade or Thermal	Small Cutters
Parting Tool	Wood Sticks
Hot Air Tool	

PROCEDURE - THERMAL PARTING METHOD

1. Select an appropriate thermal parting tip to suit the workpiece configuration. Set the nominal tip temperature, using the manufacturer's recommended procedure.

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Figure 1 Apply thermal tip to soften or granulate the material.



Figure 2 Apply hot air to the work area and remove overcured coating.

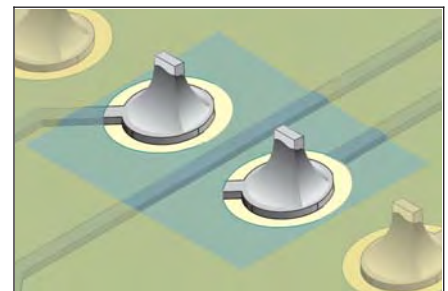


Figure 3 Removal complete.



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Number: **2.3.4**Subject: **Coating Removal, Thermal Method**Date: **1/17**

2. Apply the thermal parting tip to the coating, using a light pressure. The coating material will either soften or granulate. Polyurethanes will soften and epoxies will granulate. The tip temperature should be regulated to a point where it will effectively "break down" the coating without scorching or charring. (See Figure 1.)
3. Gradually reduce the coating thickness around the component body without contacting the board surface. Remove as much coating as possible from around component leads to allow easy removal of the leads.
Clip leads of component parts that are known to be faulty, thus permitting removal of the part body separately from leads and solder joints. Low pressure air or a brush should be used to remove the loosened coating.
4. Once sufficient coating has been removed, leaving only a small bonded joint between the part body and printed board, heat the component body with the thermal parting tool or hot air jet to weaken the bond beneath the component.
5. Lift the component body free of the printed board using small pliers.

NOTE

Twist the component prior to removal to shear any remaining epoxy bond to the printed board surface.

6. Once the component body has been removed from the board surface, the remaining coating material can be removed by additional thermal parting. The remaining leads and solder joints are then removed by appropriate solder extraction means.

PROCEDURE - HOT AIR METHOD

By control of the gas/air temperature, flow rates and jet shape, the hot air method can be applied to almost any workpiece configuration on both the component and solder side of the printed board without damage.

Extremely delicate work can be handled in this manner while permitting direct observation of the heating action.

1. Set up the hot air tool per the manufacturer's instructions. Adjust flow rate and temperature to suit specific coating removal application.

CAUTION

Never set the gas/air temperature at a level that will cause scorching or charring of the coating material or reflow the solder connections.

2. Apply the heated air jet to work area. Apply light pressure using a wood stick or other non marring tool to remove the softened or overcured coating. All coating around individual leads, solder joints and component bodies can be removed in this manner. (See Figure 2.)
3. When the coating has been removed, use appropriate solder extraction method to remove components if needed.

INSPECTION GUIDANCE

1. Visual examination or UV light may be used to verify complete removal of coating.
2. Visually inspect PCA for damage from removal of conformal coating.

NOTES

Coating Removal Required at Outlined Area



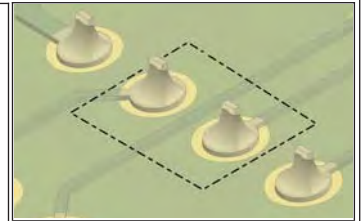
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Rework,
Modification
and Repair of
Electronic Assemblies

Date: 1/17

Number: 2.3.5

Coating Removal, Grinding/Scraping Method



Board Type: R, F, W, C
See 1.4.2
Skill Level: Advanced
See 1.4.3
Level of Conformance: High
See 1.5.1

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

This coating removal method uses various grinding and scraping tools, depending on the composition of the coating material. A knife or dental style scraper is normally used when a scraping method is desired. A hand held drill is normally used when a grinding technique is desired. A wide variety of rotary abrasive materials including ball mills may be required.

To determine the appropriate coating removal procedure the coating must first be identified. Refer to procedure number 2.3.1.

CAUTION

Abrasion operations can generate electrostatic charges.

REFERENCES

- 2.1 Handling Electronic Assemblies
- 2.2 Cleaning
- 2.3.1 Coating Removal, Identification of Conformal Coatings
- 2.4.1 Coating Replacement, Solder Resist
- 2.4.2 Coating Replacement, Conformal Coatings/Encapsulants

TOOLS AND MATERIALS

Ball Mills	Microscope
Brush	Rubberized Abrasives
Cleaner	Scraper
Cleaning Wipes	Wood Sticks
Hand Held Drill	Rubber Eraser
Knife	

PROCEDURE - SCRAPING

1. Clean the area.
2. Remove the damaged or unwanted coating or solder resist using a knife or scraper. Hold the blade perpendicular to the coating and scrape from side to side until the desired material is removed. (See Figure 1.)
3. Remove all loose material and clean the area.

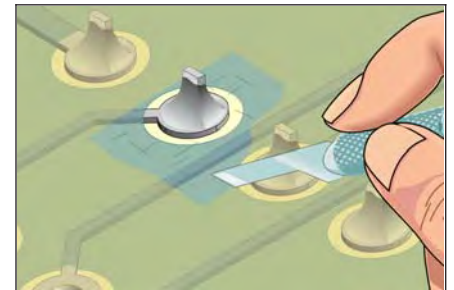


Figure 1 Scrape away damaged or unwanted coating.



Figure 2 Rubberized abrasives used to remove thin, hard coating.



Figure 3 Rotary brushes are best used to remove soft coating.

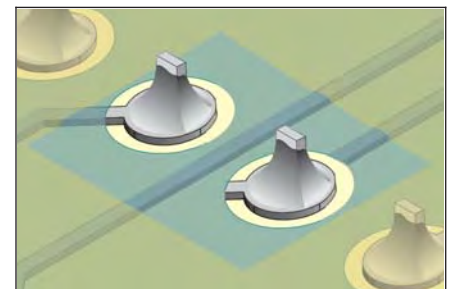


Figure 4 Removal complete.

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Page 1 of 2

Number: **2.3.5**Subject: **Coating Removal, Grinding/Scraping Method**Date: **1/17****PROCEDURE - GRINDING**

1. Clean the area.
2. Insert an abrasive tip into the hand held drill. Abrade away the damaged or unwanted coating. Move the tool from side to side to prevent damage to the printed circuit board surface. (See Figure 2.)
3. Remove all loose material and clean the area.

NOTE

Rubberized abrasives of the proper grade and grit are ideally suited for removing thin hard coatings from flat surfaces but not for soft coatings since these would cause the abrasive to "load up" with coating material and become ineffective.

Rotary brushes are better suited than rubberized abrasives on contoured or irregular surfaces, such as soldered connections, etc., since the bristles will conform to surface irregularities while removing hard or soft coatings. (See Figure 3.)

NOTE

The procedure for removing thick coatings is primarily to reduce their thickness to a thin coating and then to remove the remaining thin coating by the scraping method.

INSPECTION GUIDANCE

1. Visual examination or UV light may be used to verify complete removal of coating.
2. Visually inspect PCA for damage from removal of conformal coating.

NOTES



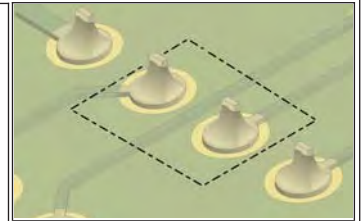
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Rework,
Modification
and Repair of
Electronic Assemblies

Number: **2.3.6**

Date: **1/17**

Coating Removal, Micro Blasting Method



Board Type: R, F, W, C
See 1.4.2
Skill Level: Advanced
See 1.4.3
Level of Conformance: High
See 1.5.1

GENERAL REQUIREMENTS

Clauses 1.7 (Basic Considerations), 1.8 (Workstations, Tools, Materials and Processes) and 1.9 (Lead Free) provide important information and guidance about the use of this procedure, including but not limited to tin-lead and lead-free alloys. This procedure is also applicable to lead free products.

OUTLINE

This coating removal method uses a micro abrasive blasting system and a very fine soft abrasive powder. The powder is propelled through a small nozzle toward the area where the coating needs to be removed.

To determine the appropriate coating removal procedure the coating must first be identified. Refer to procedure number 2.3.1.

CAUTION

Micro blasting will generate substantial static charges. The work area should be flooded with ionized air and the printed circuit board assembly should be grounded whenever possible.

REFERENCES

- 2.1 Handling Electronic Assemblies
- 2.2 Cleaning
- 2.3.1 Coating Removal, Identification of Conformal Coatings
- 2.4.1 Coating Replacement, Solder Resist
- 2.4.2 Coating Replacement, Conformal Coatings/Encapsulants

TOOLS AND MATERIALS

Abrasive Powder	Removable Mask
Polyimide Tape	Stencils
Micro Blasting System	

PROCEDURE

1. Clean the area.
2. Select the appropriate abrasive blasting powder and nozzle size. Set the air pressure at the desired setting per equipment manufacturer's instructions.
3. Apply polyimide tape or other masking material to protect the printed circuit board surface as needed. (See Figure 1.) Masking materials can consist of tapes, curable liquid masks or reusable stencils.
4. If the printed circuit board has static sensitive components, insert the entire printed circuit board into a shielded bag. Only the area needing rework should be exposed. Ground the printed circuit board to dissipate static charges if needed.

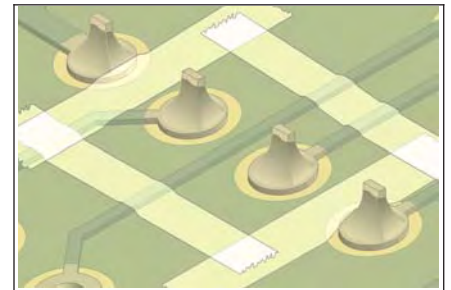


Figure 1 Apply tape to outline area for coating removal.



Figure 2 Remove coating using micro blasting system.

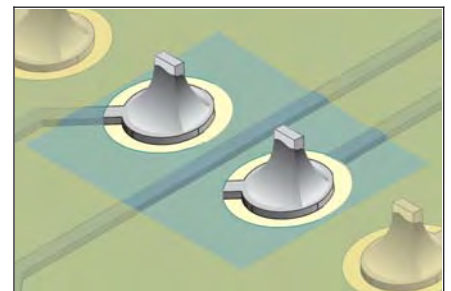


Figure 3 Removal complete.

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Number: **2.3.6**Subject: **Coating Removal, Macro Blasting Method**Date: **1/17**

5. Insert the printed circuit board into the blasting chamber and blast away the damaged or unwanted coating or solder resist. Slowly move the nozzle along the area where the coating is to be removed. (See Figure 2.)
6. Blow off the blasting dust and clean the area.

INSPECTION GUIDANCE

1. Visual examination or UV light may be used to verify complete removal of coating.
2. Visually inspect PCA for damage from removal of conformal coating.
3. Visually inspect and verify no evidence of micro blasting material is present.

NOTES