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Vice President & Technical Director, EPTAC

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IPC-AJ-820A
2012 - February
Assembly and Joining Handbook

Supersedes IPC-AJ-820
April 1997

A standard developed by IPC

IPC-AJ-820A – Assembly and Joining Handbook

The "How and Why" of All Things PCB & PCA

Association Connecting Electronics Industries

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Scope

- To provide guidelines and supporting info for the mfg of electronic equipment
- To explain the **HOW TO** and **WHY**
  - Discussions on appropriate assembly and joining techniques for electronic assembly
- To provide reference documents where needed

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Section 2 - Handling

Proper handling is required to prevent damage:

- Due to electrostatic discharge,
- Caused by high temperatures experienced during reflow,
- To non-hermetically sealed components that are not maintained in a moisture free environment or otherwise baked prior to reflow soldering.

Section 2 - Handling

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Table 2-3 General Rules for Handling Electronic Assemblies

1	Keep work stations clean and neat. There should 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 should be changed as frequently as necessary to prevent contamination from dirty gloves.
4	Solderable surfaces should not 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	Hand creams or lotions containing silicone should be avoided since they can cause solderability and conformal coating adhesion problems.
6	Never stack electronic assemblies on each other or physical damage may occur. Special racks should be provided in assembly areas for temporary storage.
7	Always assume the items are ESDS even if they are not marked.
8	Personnel should be trained and follow appropriate ESD practices and procedures.
9	Never transport ESDS devices unless proper packaging is applied.

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Section 3 Design Considerations

- This section provides general assembly and joining information that pertains to the design of PCAs

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Section 3 Design Considerations

- Design of an efficient and integrated design team will give all disciplines the visibility needed to best utilize the equipment and talents available within a company.
- A typical team will involve the Project Manager, Design Engineering, Components Engineering, Process Engineering, Reliability, Manufacturing Engineering, Tooling Design, Quality, and Material.

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Section 3 Design Considerations

The team should ask the following:

- What technology to use
- What is the end product usage
- What kind of performance and reliability does it need
- How will it be put together
  - What kind of solder to use
  - What kind of laminate to use
- Will it be required to rework the failures
- How will it be tested

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Section 4 Printed Circuits

- A PCB should be selected for optimum thermal, mechanical, and electrical systems reliability. However, each candidate structure has particular advantages and disadvantages when compared to the others
- No one particular PCB will satisfy all of the needs of an application. The designer seeks a compromise of properties best tailored for component attachment and circuit reliability

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Section 4 Printed Circuits

- The basic function of printed boards is to provide support for circuit components and to interconnect them electrically.
- To achieve this, numerous PCB structure types varying in base dielectric material, conductor type, number of conductor planes, rigidity, etc. have been developed.

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Section 4 Printed Circuits

Design Issues

- Will product use PTH , SMT or both Technologies
- What are the CTE issues
- Laminate Selection
- Foil type and thickness
- Coatings
  - Solderable finishes

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Section 5 Components

- This Section of the Handbook provides general information pertaining to electronic circuit components and terminations with respect to their impact on the assembly and joining of electronic printed board assemblies.
- All components should be compatible with the assembly processes used.
- The components/parts should also be able to withstand exposure to all the chemicals used in the manufacturing process such as adhesive bonding, soldering, cleaning, and any other chemistries used in the process.

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Section 5 Components

Things of concern

- Package Dimension
- Heat Dissipation capability
- Manufacturability
- Yield
- Number of interconnects
- Complexity
- Testability
- Compatibility with Mfg process
- Moisture sensitivity

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Section 5 Components

- Section also covers counterfeit components and some history on how components get into the supply chain from this market.

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Section 6 Solderability

Assessment of the

- Impact of different component and/or printed wiring board fabrication processes on surface finish quality
- Incoming component and/or printed wiring board surface finish quality
- Impact of storage conditions on component and/or printed wiring board surface finishes
- Component and/or printed wiring board surfaced finish prior to assembly operations as part of a “Just In Time” (JIT) protocol

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Section 7 Assembly and Joining Materials

- As electronic packaging developed the soldering equipment and materials have become more technically advanced.
- High production soldering equipment has improved and it allows the simultaneous joining of hundreds of electrical terminations.
- Many connections could be made with other methods, but soldering continues to be the most reliable and least costly means of joining metals in the electronics industry.

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Section 7 Assembly and Joining Materials

This section covers

- Fluxes and types
- Solder and various alloys
- Solder paste and paste evaluation
- Adhesives
  - Epoxy
  - Silicones
  - Polyurethane
  - Acrylic
  - Cyanoacrylates

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Section 7 Assembly and Joining Materials

PCBs and Finishes

This section also has a couple of tables which are important in helping make a decision on Whiskers and lead free introduction.

Table 7-10 also discusses the Test protocols for Pb-free soldering

Table 7-12 Tin Whiskers Mitigation

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Section 7 Assembly and Joining Materials

7-9 A. Tin Whiskers - observed problems caused by whiskers:

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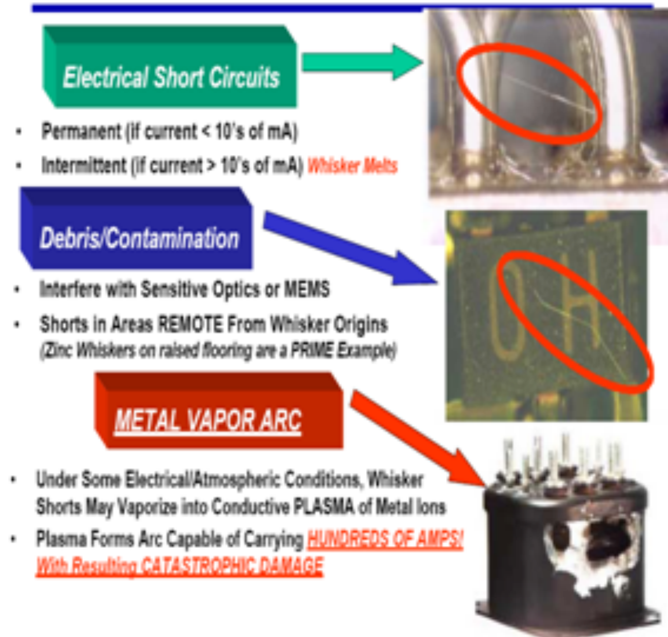
Section 7 Assembly and Joining Materials

A "Few" Reported Metal Whisker Problems
(Only the Last 15-20 Years Considered)

	Year**	Application	Industry	Failure Cause	Whiskers on?
1	1986	Heart Pacemakers	Medical (RECALL)	Tin Whiskers	Crystal Can
2	1986	MIL Aircraft Radar	Military	Tin Whiskers	Hybrid Package
3	1987	MIL/Aerospace PWB	MIL/Aerospace	Tin Whiskers	PWB traces
4	1988	Missile Program "A"	Military	Tin Whiskers	Relays
5	1989	Missile Program "B"	Military	Tin Whiskers	Electronics Encl
6	1990	Apnea Monitors	Medical (RECALL)	ZINC Whiskers	Rotary Switch
7	1992	Missile Program "C"	Military	Tin Whiskers	Xsistor Package
8	1993	Govt. Electronics	Govt. Systems	Tin Whiskers	Transistor, Diod
9	1995	Telecom Equipment	Telecom	ZINC Whiskers	Framework
10	1996	Computer Routers	Computers	ZINC Whiskers	Chassis
11	1996	MIL Aerospace	MIL Aerospace	Tin Whiskers	Relays
12	1998	Aerospace Electronics	Space	Tin Whiskers	Hybrid Package
13	1998	Commercial Satellite #1	Space (Complete Loss)	Tin Whiskers	Relays
14	1998	Commercial Satellite #2	Space	Tin Whiskers	Relays
15	1998	Commercial Satellite #3	Space	Tin Whiskers	Relays
16	1998	Computer Hardware	Computers	ZINC Whiskers	Chassis
17	1998	Military Aerospace	Military Aerospace	Tin Whiskers	Plastic Film Cap
18	1999	Eng Computer Center	Architectural	ZINC Whiskers	Floor Tiles
19	199X	Telecom Equipment	Telecom	ZINC Whiskers	PSU Housing
20	2000	Missile Program "D"	Military	Tin Whiskers	Terminals
21	2000	Commercial Satellite #4	Space (Complete Loss)	Tin Whiskers	Relays

Many of these Incidents Involve "Multiple" Failures

November 2003 A Discussion of Metal Whisker Formation



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Section 8 Component Mounting

- This section covers the requirements for the preparation of components for soldering on Printed Circuit Boards. Further information can be found in IPC-CM-770 – Guidelines for Printed Board Component Mounting.
- Most of the remaining material in this section is in IPC-A-610, Component Mounting, PTH, SMT along with the Rules and Requirements

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Section 8 Component Mounting

8.1.1 Producibility Levels

Producibility levels are a method of communicating between design and fabrication/assembly facilities the degree of difficulty of assembling a circuit card assembly. These levels are:

- Level A – Through-hole component mounting only
- Level B – Surface mounted components only
- Level C – Low complexity through-hole and surface mount intermixed assembly
- Level X – Complex intermixed assembly, through-hole, surface mount, fine pitch, and BGA
- Level Y – Complex intermixed assembly, through-hole, surface mount, ultra fine pitch, and chip scale
- Level Z – Complex intermixed assembly, through-hole, ultra fine pitch, COB, flip chip, and TAB

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Section 9 Soldering

- Covers wetting and solderability
- Solder Alloys
  - Intermetallic Compounds and Growth rates.
- Strain Rates
- Impact of thermal cycling on grain size growth rates

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Section 9 Soldering

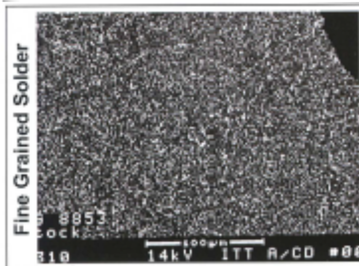

Figure 9-7 Solder Joint Grain Size Structure (As Soldered) Courtesy of Nicholas Gollmer, ITT Automotive, USA

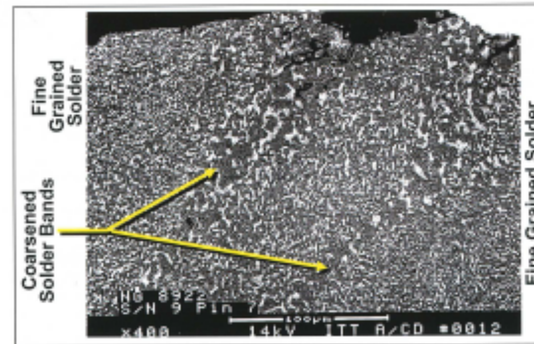

Figure 9-8 Solder Joint Grain Size Structure (After accelerated Cycling) Courtesy of Nicholas Gollmer, ITT Automotive, USA

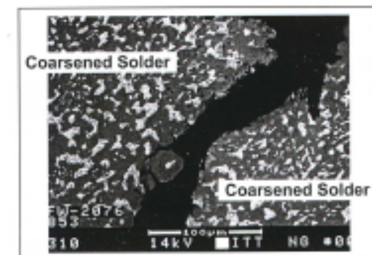

Figure 9-9 Solder Joint Grain Size Structure (After Field Failure) Courtesy of Nicholas Gollmer, ITT Automotive, USA

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Section 9 Soldering

Lead-free soldering process Considerations

- Copper dissolution
- Elemental metal contamination

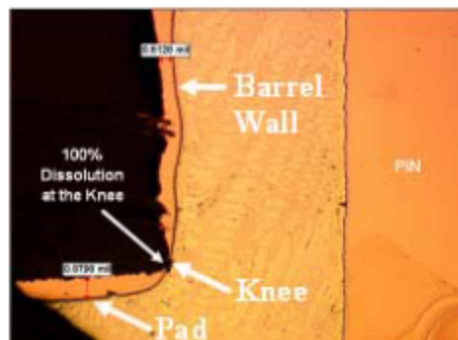

Figure 2. Hidden Defect

A STUDY OF COPPER DISSOLUTION DURING LEAD FREE PTH REWORK USING A THERMALLY MASSIVE TEST VEHICLE

Craig Hamilton and Polina Snugovsky
Celestica Inc.
Toronto, ON, Canada

Matthew Kelly
IBM Corporation
Toronto, ON, Canada

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Section 9 Soldering

- Soldering Irons
  - Tip selection and maintenance

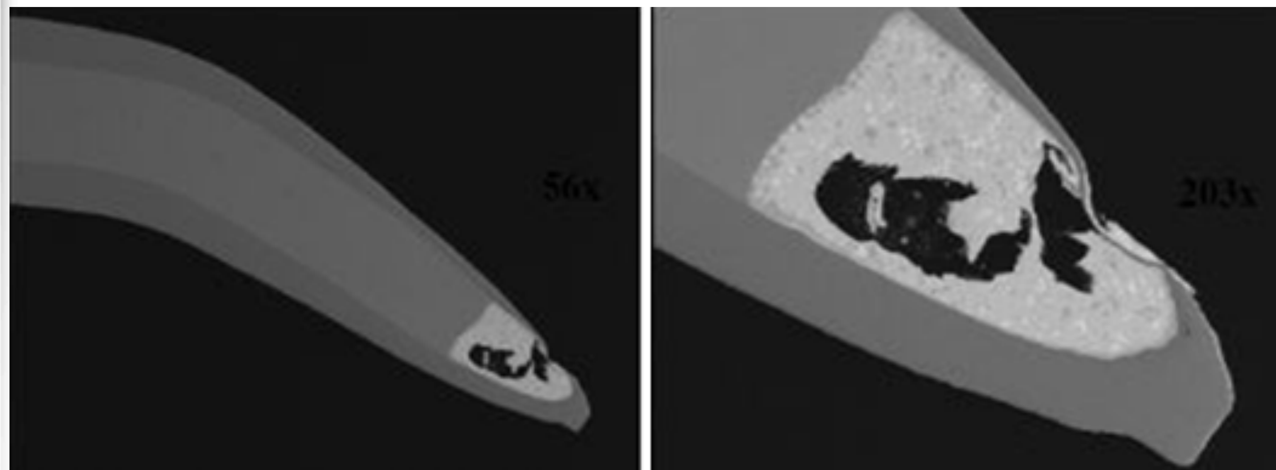

Figure 9-18 Lead-free Soldering Iron Tip Damage (Courtesy of Hakko)

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Section 9 Soldering

- Terminal Soldering
  - Turret and Hook Terminals
  - Cups
- PTH Soldering

Table 9-8 Supported Holes with Component Leads, Minimum Acceptable Conditions Note

	Criteria	Class 1	Class 2	Class 3
A	Vertical fill of solder. Note 2	Not specified	75%	75%
B	Circumferential wetting of lead and barrel on solder destination side.	Not specified	180°	270°
C	Percentage of original land area covered with wetted solder on solder destination side.	0	0	0
D	Circumferential fillet and wetting of lead and barrel on solder source side.	270°	270°	330°
E	Percentage of original land area covered with wetted solder on solder source side. Note 1	75 %	75 %	75 %

Note 1. Wetted solder refers to solder applied by any solder process including intrusive soldering. For intrusive soldering there may not be an external fillet between the lead and the land.
Note 2. The 25% unfilled height includes the sum of both source and destination side depressions.

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Section 9 Soldering

- Machine soldering
  - Wave and Selective Wave
    - Flux
    - Preheat
    - Solder temp
- Dross Recovery
- Thermal profiling
- Vapor Phase Soldering

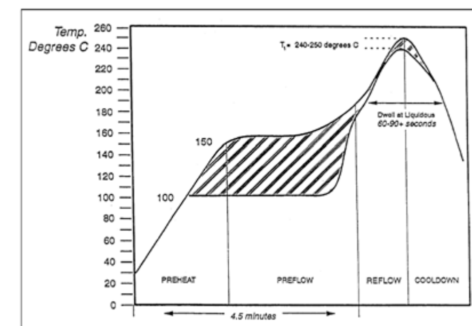

Figure 9-24 Typical "No-Clean" Flux Thermal profile

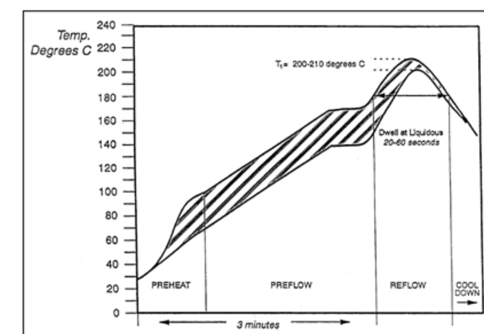

Figure 9-23 Typical Type OA Flux Thermal Profile

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Section 10
Other Assembly and Joining Methods

- Wire Bonding
- Thermocompression TC Bonding
- Ultrasonic Bonding
- Tape Automated Bonding (TAB)
- Wire Wrapping

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Section 11 Cleaning

- Why clean?
- How Clean is clean?
- Historical overview of cleaning
- Pre and post soldering Cleaning
- Semi-Aqueous cleaning
- Solvent cleaning

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Section 12
Conformal Coating

12.1 Function of Conformal Coating

- Conformal coatings have primary and secondary functions, depending on the end-use application. Primary functions include:
- Inhibit current leakage and short circuit due to humidity and contamination from the service environment
- Inhibit arcing, corona effects
- Serve as a barrier to liquid water falling on energized circuits
- Serve as a barrier to harmful fluids and gasses and to inhibit corrosion from such materials
- Serve as a barrier against Foreign Objects and Debris (FOD) contacting energized circuits

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Section 12
Conformal Coating

- Secondary functions include:
- Improve fatigue life of solder joints to leadless packages
- Provide mechanical support for small parts that cannot be secured by mechanical means, to prevent damages due to mechanical shock and vibration.
- Provide mitigation against tin whiskers for lead-free applications
- Provide fungus resistance for components that are not fungus resistant
- Provide supplemental flammability mitigation for components that are not expressly flame-proof

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Section 13
Potting and Encapsulation

13.2 Purpose

- The purpose of this handbook is to assist the individuals who must either make choices regarding encapsulation or who must work in encapsulation operations.
- This handbook represents the compiled knowledge and experience of various industry sources. It is not enough to understand the properties of the various encapsulation. You must understand what you want to achieve by applying the encapsulation and how to verify that you have achieved the desired results.

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Section 14
Rework and Repair

Scope

This revision includes expanded coverage for the lead-free processes, and additional inspection guidelines for operations such as repair that may not have other published criteria. This section does not limit the maximum number of rework, modification or repair actions to a PCB.

Purpose

Although this section 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.

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Thank You

Questions?

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Further Information

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800-643-7822 ext 215

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