



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES®

IPC-HDBK-610

Handbook and Guide
to IPC-A-610
(Includes IPC-A-610B
to C Comparison)

IPC-HDBK-610

September 2002

A standard developed by IPC

2215 Sanders Road, Northbrook, IL 60062-6135

Tel. 847.509.9700 Fax 847.509.0700

 **Documents**
www.ipc.org
Document Sharing Hub

The Principles of Standardization

In May 1995 the IPC's Technical Activities Executive Committee adopted Principles of Standardization as a guiding principle of IPC's standardization efforts.

Standards Should:

- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:

- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

Notice

IPC Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such Standards and Publications shall not in any respect preclude any member or nonmember of IPC from manufacturing or selling products not conforming to such Standards and Publication, nor shall the existence of such Standards and Publications preclude their voluntary use by those other than IPC members, whether the standard is to be used either domestically or internationally.

Recommended Standards and Publications are adopted by IPC without regard to whether their adoption may involve patents on articles, materials, or processes. By such action, IPC does not assume any liability to any patent owner, nor do they assume any obligation whatever to parties adopting the Recommended Standard or Publication. Users are also wholly responsible for protecting themselves against all claims of liabilities for patent infringement.

IPC Position Statement on Specification Revision Change

It is the position of IPC's Technical Activities Executive Committee (TAEC) that the use and implementation of IPC publications is voluntary and is part of a relationship entered into by customer and supplier. When an IPC standard/guideline is updated and a new revision is published, it is the opinion of the TAEC that the use of the new revision as part of an existing relationship is not automatic unless required by the contract. The TAEC recommends the use of the latest revision.
Adopted October 6, 1998

Why is there a charge for this standard?

Your purchase of this document contributes to the ongoing development of new and updated industry standards. Standards allow manufacturers, customers, and suppliers to understand one another better. Standards allow manufacturers greater efficiencies when they can set up their processes to meet industry standards, allowing them to offer their customers lower costs.

IPC spends hundreds of thousands of dollars annually to support IPC's volunteers in the standards development process. There are many rounds of drafts sent out for review and the committees spend hundreds of hours in review and development. IPC's staff attends and participates in committee activities, typesets and circulates document drafts, and follows all necessary procedures to qualify for ANSI approval.

IPC's membership dues have been kept low in order to allow as many companies as possible to participate. Therefore, the standards revenue is necessary to complement dues revenue. The price schedule offers a 50% discount to IPC members. If your company buys IPC standards, why not take advantage of this and the many other benefits of IPC membership as well? For more information on membership in IPC, please visit www.ipc.org or call 847/790-5372.

Thank you for your continued support.



ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES®

IPC-HDBK-610

Handbook and Guide to IPC-A-610 (Includes IPC-A-610B to C Comparison)

Developed by the IPC-HDBK-610 Task Group (7-31g) of the Product Assurance Committee (7-30) of IPC

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

Contact:

IPC
2215 Sanders Road
Northbrook, Illinois
60062-6135
Tel 847 509.9700
Fax 847 509.9798



Acknowledgment

Any Standard involving a complex technology draws material from a vast number of sources. While the principal members of the IPC-HDBK-610 Task Group (7-31g) 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.

Product Assurance Committee

Chair
Mel Parrish
Soldering Technology International

IPC-HDBK-610 Task Group

Co-Chairs
Blen F. Talbot
L-3 Communications

Sharon T. Ventress
U.S. Army Aviation & Missile Command

IPC-HDBK-610 Task Group

David C. Adams, Rockwell Collins	Vicky Freeman, Solectron Tech, Inc.	Barry Morris, Advanced Rework Technology-A.R.T
Michael Aldrich, Analog Devices Inc.	Mahendra S. Gandhi	Mary Muller, Eldec Corporation
Becky Amundsen, Northrop Grumman Corporation	Constantino J. Gonzalez, ACME, Inc.	Kim Norris, Lockheed Martin
Peter Ashaolu, Cisco Systems Inc.	Michael R. Green, Lockheed Martin Space Systems	Riley L. Northam, EMPF/ACI
Craig Bennett, NSWC - Crane	Hue T. Green, Lockheed Martin Space Systems	John S. Norton, Xerox Corporation
Ken Bloomquist, General Dynamics IT	C. Dudley Hamilton, Lockheed Martin Corporation	Gregg Owens, Manufacturing Technology
Gerald Leslie Bogert, Bechtel Plant Machinery, Inc.	Steven A. Herrberg, Raytheon Systems Company	Deepak K. Pai, C.I.D.+, General Dynamics-Advanced Information
Leroy Boone, Thomson Consumer Electronics	Constantin Hudon, Varitron Technologies Inc.	Mel Parrish, Soldering Technology International
Sudhir T. Bora, Automotive Systems Laboratory Inc.	Greg Hurst, BAE SYSTEMS	Peter A. Phillips
William G. Butman, AssemTech Skills Training Corp.	Dr. Jennie S. Hwang, H-Technologies Group Inc.	David Posner, Thermo Gamma-Metrics
Thomas A. Carroll, Boeing Satellite Systems	Les Hymes, The Complete Connection	John Ragland, Astronautics Corp. of America
Alan S. Cash, Northrop Grumman Corporation	James Jenkins, Harris Corporation, GCSD	Guy M. Ramsey, EMPF/ACI
Jennifer Day, Current Circuits, Inc.	Vijay Kumar, Lockheed Martin Missile & Fire Control	Teresa M. Rowe, AAI Corporation
William C. Dieffenbacher, BAE Systems Controls	John Mastorides, Sypris Electronics, LLC	Steven T. Sauer, Xetron Corp.
Barrie D. Dunn, European Space Agency	Wade McFaddin, Nextek, Inc.	Al F. Schmidt, Schippers & Crew, Inc.
Kathy Edsinger, Plexus Corp.	Garry D. McGuire, NASA/Goddard Space Flight Center	Vern Solberg, Tessera Technologies, Inc.
Jason Ferguson, NSWC - Crane	William E. McManes, PEI Electronics, Inc.	Blen F. Talbot, L-3 Communications
Jeff Ferry, Circuit Technology Center Inc.	Randy McNutt, Northrop Grumman	Linda Tucker, Blackfox Training Institute
Daniel L. Foster, Soldering Technology International	James H. Moffitt, Moffitt Consulting Services	Sharon T. Ventress, U.S. Army Aviation & Missile Command
Michael Freed, Rockwell Automation/Allen-Bradley	Ken A. Moore, Omni Training Corp.	Karen Walters, BTU International
		Ge Wang, TRW Electronics & Technology Division
		Don Youngblood, Honeywell Inc.

TABLE OF CONTENTS

Sorted in IPC-A-610 Revision C Order

IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
1	1-1	Forward	iv	1	1	Acceptability of Electronic Assemblies
				1.0.1	1	Preamble/Forward
				1.0.2	1	Format of this Handbook
				1.0.3	1	Supplemental Definitions
				1.0.4	2	Background on IPC-A-610 Revision C
1.1	1-1	Forward	iv	1.1	2	Scope
1.2	1-1	Forward	iv	1.2	2	Purpose
1.3	1-2			1.3	3	Specialized Designs
1.4	1-2			1.4	3	Terms & Definitions
1.4.1	1-2	Forward	iv	1.4.1	3	Classification
1.4.2	1-2	Forward	iv	1.4.2	4	Customer Responsibility
1.4.3	1-2	Forward	iv	1.4.3	4	Acceptance Criteria
1.4.3.1	1-2	Forward	iv	1.4.3.1	4	Target Condition
1.4.3.2	1-3	Forward	iv	1.4.3.2	4	Acceptable Condition
1.4.3.3	1-3	Forward	iv	1.4.3.3	5	Defect Condition
1.4.3.4	1-3	Forward	iv	1.4.3.4	5	Process Indicator Condition
1.4.3.5	1-3			1.4.3.5	6	Conditions Not Specified
1.4.4	1-3	Forward	vii	1.4.4	6	Board Orientation
1.4.4.1	1-3	Forward	vii	1.4.4.1	7	Primary Side
1.4.4.2	1-3	Forward	vii	1.4.4.2	7	Secondary Side
1.4.4.3	1-3			1.4.4.3	7	Solder Source Side
1.4.4.4	1-3			1.4.4.4	7	Solder Destination Side
1.4.5	1-3			1.4.5	7	Electrical Clearance
1.4.6	1-3			1.4.6	8	Cold Solder Connection
1.4.7	1-4			1.4.7	8	Leaching
1.4.8	1-4			1.4.8	8	Meniscus (Component)
1.5	1-4			1.5	8	Examples and Illustrations
				1.5.0.1	8	Graphic Aids
				1.5.0.2	8	Flowdown of Requirements
				1.5.0.3	9	Applying Appropriate Criteria
1.6	1-4			1.6	8	Inspection Methodology
1.7	1-4	Forward	vii	1.7	9	Verification of Dimensions
1.8	1-4	Forward	vii	1.8	9	Magnification Aids and Lighting
2	2-1			2	11	Applicable Documents
2.1	2-1			2.1	11	IPC Documents
2.2	2-1			2.2	11	Joint Industry Documents
2.3	2-2			2.3	12	EOS/ESD Association Documents
2.4	2-2			2.4	12	Electronics Industries Alliance Documents
2.5	2-2			2.5	12	International Electrotechnical Commission Documents
				2.6	12	Federal Standards
3	3-1	1	1	3	13	Handling Electronic Assemblies
3.1	3-2	1.1	2	3.1	13	Electrical Overstress (EOS) Damage Prevention
3.2	3-3	1.1	2	3.2	13	Electrostatic Discharge (ESD) Damage Prevention

IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
3.2.1	3-4	1.1.1	3	3.2.1	13	Warning Labels
3.2.2	3-5	1.1.2	4	3.2.2	13	Protective Materials
3.3	3-6	1.2	4	3.3	14	EOS/ESD Safe Workstation/EPA
3.4	3-8	1.3	5	3.4	16	Handling
3.4.1	3-8	1.3	5	3.4.1	16	Guidelines
3.4.2	3-9	1.3	5	3.4.2	16	Physical Damage
3.4.3	3-9	1.3	5	3.4.3	16	Contamination
3.4.4	3-9	1.3	6	3.4.4	16	Electronic Assemblies
3.4.5	3-10	1.3	6	3.4.5	16	After Soldering
3.4.6	3-11	1.3	6	3.4.6	16	Gloves and Finger Cots
4	4-1	2.0	7	4	17	Mechanical Assembly
4.1	4-2	2.1	8	4.1	17	Hardware
4.2	4-3	2.2	8	4.2	17	Hardware Mounting
4.2.1	4-3	2.2.1	8	4.2.1	17	Electrical Clearance
4.2.2	4-4	4.2	55	4.2.2	17	Excess Solder
4.2.3	4-5	2.2.2	9	4.2.3	17	Threaded Fasteners
4.2.3.1	4-8			4.2.3.1	18	Minimum Torque for Electrical Connections
4.2.3.2	4-9			4.2.3.2	18	Wires
4.2.3.3	4-11			4.2.3.3	18	High Voltage Applications
4.2.4	4-12	2.2.3	10	4.2.4	18	Component Installation
4.2.4.1	4-12	2.2.3.1	10	4.2.4.1	18	High Power
4.2.4.2	4-14	2.2.3.2	11	4.2.4.2	18	Hole Obstruction for Solder Fill
4.3	4-15	2.3	11	4.3	19	Swaged Hardware
4.3.1	4-16	2.3.1	12	4.3.1	19	Flared Flange
4.3.1.1	4-17	2.3.1.1	13	4.3.1.1	19	Controlled Split
4.3.2	4-19	2.3.2	14	4.3.2	19	Flat Flange - Fused-in-Place
4.3.3	4-21	2.3.3	15	4.3.3	19	Terminals
4.4	4-22	2.4	15	4.4	19	Component Mounting
4.4.1	4-23	2.4.1	16	4.4.1	19	Mounting Clips
4.4.2	4-25	2.4.2	17	4.4.2	20	Adhesive Bonding - Non-Elevated Components
4.4.3	4-27	2.4.3	18	4.4.3	20	Adhesive Bonding - Elevated Components
4.4.4	4-28	2.4.4	20	4.4.4	20	Wire Hold Down
4.4.5	4-29	2.4.5	20	4.4.5	20	Cable Ties, Tie Wraps, Spot Ties
4.4.6	4-32	2.4.6	21	4.4.6	20	Lacing
4.4.7	4-33			4.4.7	20	Wire Dress for Terminations to Connectors Without Strain/Stress Relief
4.5	4-34	2.5	22	4.5	20	Connectors, Handles, Extractors
4.6	4-35	2.6	22	4.6	21	Heat Sink
4.6.1	4-37	2.6.1	23	4.6.1	21	Insulators and Thermal Compounds
4.6.2	4-38	2.6.2	24	4.6.2	21	Contact
4.7	4-39	2.7	24	4.7	21	Terminals - Edge Clip
4.8	4-40	2.8	25	4.8	21	Connector Pins
4.8.1	4-41	2.8.1	25	4.8.1	21	Edge Connector Pins
4.8.2	4-42	2.8.2	26	4.8.2	21	Press-Fit Pins
5	5-1	3	29	5	22	Component Installation Location/ Orientation
5.1	5-2	3.1	30	5.1	22	Orientation
5.1.1	5-2	3.1.1	30	5.1.1	22	Horizontal
5.1.2	5-4	3.1.2	31	5.1.2	22	Vertical

IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
5.2	5-5	3.2	31	5.2	22	Mounting
5.2.1	5-5	3.2.1	31	5.2.1	22	Horizontal - Axial Leaded - Supported Holes
5.2.2	5-7			5.2.2	22	Horizontal - Axial Leaded - Unsupported Holes
5.2.3	5-8	3.2.2	32	5.2.3	22	Horizontal - Radial Leaded
5.2.4	5-9	3.2.3	32	5.2.4	23	Vertical - Axial Leaded - Supported Holes
5.2.5	5-11			5.2.5	23	Vertical - Axial Leaded Unsupported Holes
5.2.6	5-12	3.2.4	33	5.2.6	24	Vertical - Radial Leaded
5.2.6.1	5-13	2.4.3.1	19	5.2.6.1	24	Component Mounting Spacers
5.2.6.2	5-15	3.2.4	34	5.2.6.2	24	Component Meniscus
5.2.7	5-16	3.5.3	47	5.2.7	25	Wire/Lead Termination - Printed Board
5.2.7.1	5-16	3.5.3.1	47	5.2.7.1	25	Protrusion - Straight and Partially Clinched Leads
5.2.7.2	5-17	3.5.3.2	48	5.2.7.2	25	Clinched
5.2.8	5-19	3.2.5	34	5.2.8	26	Dual-In-line Pack (DIP)/Single-In-line Pack (SIP) Pins and Sockets
5.2.9	5-21	3.2.6	35	5.2.9	26	Connectors
5.2.10	5-23	3.2.7	36	5.2.10	26	Leads Crossing Conductors
5.3	5-24	3.3	38	5.3	26	Lead Forming
5.3.1	5-24	3.3	38	5.3.1	26	Bends
5.3.2	5-26	3.2.8	36	5.3.2	27	Stress Relief
5.3.2.1	5-26			5.3.2.1	27	Supported Holes
5.3.2.2	5-28			5.3.2.2	27	Unsupported Holes
5.3.2.3	5-29	3.2.8.1	37	5.3.2.3	27	Terminals
5.4	5-30	3.4	38	5.4	27	Damage
5.4.1	5-30	3.4.1	38	5.4.1	27	Lead
5.4.2	5-32	3.4.2	39	5.4.2	28	DIP and SOIC
5.4.3	5-33	3.4.3	39	5.4.3	28	Axial Lead and Glass Body/Seal
5.4.4	5-35	3.4.4	40	5.4.4	28	Radial (Two Lead)
5.5	5-36	3.5.1	40	5.5	28	Terminals
5.5.1	5-36	3.5.1.1	40	5.5.1	28	Wrap
5.5.1.1	5-37			5.5.1.1	28	Turrets and Straight Pins
5.5.1.2	5-38			5.5.1.2	28	Bifurcated Terminals
5.5.1.3	5-41			5.5.1.3	29	Pierced/Perforated Terminals
5.5.1.4	5-42			5.5.1.4	29	Hook Terminals
5.5.1.5	5-44			5.5.1.5	29	Series Connected Terminals
5.5.1.6	5-45			5.5.1.6	29	AWG 30 and Smaller Diameter Wires
5.5.1.7	5-46			5.5.1.7	29	Staked Wires/Components
5.5.2	5-47			5.5.2	29	Solder Cups
5.5.3	5-48	3.5.1.3	43	5.5.3	29	Stress Relief Lead/Wire Bend
5.5.4	5-50			5.5.4	30	Service Loops
5.5.5	5-51	3.5.1.4	44	5.5.5	30	Lead/Wire Placement
5.6	5-52	3.5.2	45	5.6	30	Insulation
5.6.1	5-52	3.5.2.1	45	5.6.1	30	Clearance
5.6.2	5-53	3.5.2.2	46	5.6.2	30	Damage
5.6.3	5-54	3.5.4	49	5.6.3	31	Flexible Sleeve
5.7	5-55	3.5.2.3		5.7	31	Conductor
5.7.1	5-55	3.5.2.3	46	5.7.1	31	Deformation
5.7.2	5-57	3.5.2.3	47	5.7.2	31	Damage
6	6-1	4	51	6	32	Soldering



IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
6.1	6-2	4.1	52	6.1	32	Soldering Acceptability Requirements
		4.1	52	6.1.0.1	32	Wetting
				6.1.0.2	32	Wetting and Solderability
				6.1.0.3	33	Solder Connections to Gold Plated Leads
6.2	6-4			6.2	33	Lead Protrusion
6.3	6-5	4.2	54	6.3	33	Plated-Through Holes (PTH) (Supported Holes)
6.3.1	6-6	4.1	52	6.3.1	33	Vertical Fill of Hole
6.3.2	6-8	4.1	52	6.3.2	34	Circumferential Wetting - Primary Side
6.3.2.1	6-8	4.1	52	6.3.2.1	34	Lead and Barrel
6.3.2.2	6-9	4.1	52	6.3.2.2	34	Land Area Coverage - Primary Side
6.3.3	6-10	4.1	52	6.3.3	34	Circumferential Wetting - Secondary Side (PTH and Unsupported Holes)
6.3.4	6-11	4.2	54	6.3.4	34	PTH Mounted Components
6.3.4.1	6-11			6.3.4.1	34	Solder Conditions
6.3.4.2	6-13			6.3.4.2	34	Solder in Lead Bend
6.3.4.3	6-14	4.2	57	6.3.4.3	34	Meniscus in Solder
6.3.5	6-15			6.3.5	35	Coated Wire Insulation in Solder
6.3.6	6-16	4.2.4	57	6.3.6	35	Interfacial Connection without Lead - Vias
6.4	6-17			6.4	35	Unsupported Holes
6.5	6-20			6.5	35	Other
6.5.1	6-20	4.2.2	56	6.5.1	35	Lead Cutting After Soldering
6.5.2	6-21	4.2.1	56	6.5.2	35	Exposed Basis Material
6.5.3	6-23	4.1	52	6.5.3	36	Excess Solder
6.5.3.1	6-23	4.1	53	6.5.3.1	36	Solder Balls/Splashes
6.5.3.2	6-24	4.1	52	6.5.3.2	36	Solder Bridging
6.5.3.3	6-25	4.1	53	6.5.3.3	36	Solder Webbing
6.5.4	6-26	4.1	52	6.5.4	36	Pin Holes/Blow Holes
6.5.5	6-27	4.2	55	6.5.5	36	Soldering Projections
6.5.6	6-28			6.5.6	36	Nonwetting
6.6	6-29	4.3	58	6.6	37	Terminals
6.6.1	6-30			6.6.1	37	Bifurcated
6.6.2	6-31			6.6.2	37	Turret
6.6.3	6-32			6.6.3	37	Hook/Pin
6.6.4	6-33			6.6.4	37	Pierced Tab
6.6.5	6-34			6.6.5	37	Solder Cups
6.6.6	6-35			6.6.6	38	Flared Flange Hardware
6.7	6-37	4.3.1	58	6.7	38	Insulation
6.7.1	6-37	4.1	53	6.7.1	38	In Solder
6.7.2	6-38	4.1	53	6.7.2	38	Damage
6.7.3	6-39			6.7.3	38	Clearance
6.8	6-40			6.8	38	High Voltage
6.8.1	6-40			6.8.1	39	Terminals
6.8.1.1	6-40			6.8.1.1	39	Wires/Leads
6.8.1.2	6-42			6.8.1.2	39	Bottom Terminations
6.8.1.3	6-43			6.8.1.3	39	Unused
6.8.2	6-44			6.8.2	39	Solder Cups
6.8.2.1	6-44			6.8.2.1	39	Wires/Leads
6.8.2.2	6-45			6.8.2.2	39	Unused

IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
6.8.3	6-46			6.8.3	39	Insulation
6.8.4	6-47			6.8.4	39	Through-Hole Connections
6.8.5	6-48			6.8.5	39	Flared Flange Terminals
6.9	6-49	4.5	60	6.9	39	Connector Pins - Press-Fit Pins
6.10	6-51	4.4	60	6.10	39	Gold Fingers
7	7-1	5	63	7	40	Cleanliness
7.1	7-2	5.1	64	7.1	40	Flux Residues
7.2	7-3	5.2	65	7.2	40	Particulate Matter
7.3	7-4	5.3	65	7.3	40	Chlorides, Carbonates, and White Residues
7.4	7-6			7.4	41	Flux Residues - No Clean Process Appearance
7.5	7-7	5.4	66	7.5	41	Surface Appearance
8	8-1	6	67	8	42	Marking
8.1	8-2	6.1	68	8.1	42	Etched Marking (including Hand Printing)
8.2	8-3	6.2	69	8.2	42	Screened Marking
8.3	8-3	6.3	70	8.3	42	Stamped Marking
8.4	8-6	6.4	71	8.4	42	Laser Marking
8.5	8-8	6.5	72	8.5	42	Labels
8.5.1	8-8	6.5	72	8.5.1	42	Bar Coding
8.5.2	8-8	6.5.1	72	8.5.2	42	Readability
8.5.3	8-9	6.5.2	72	8.5.3	42	Adhesion and Damage
9	9-1	7	73	9	43	Coatings
9.1	9-2	7.1	74	9.1	43	Conformal Coating
9.1.1	9-2	7.1.1	74	9.1.1	43	General
9.1.2	9-3	7.1.2	74	9.1.2	43	Coverage
9.1.3	9-6	7.1.3	75	9.1.3	43	Thickness
9.2	9-7	7.2	76	9.2	43	Solder Resist Coating
9.2.1	9-8	7.2.1	76	9.2.1	43	Wrinkling/Cracking
9.2.2	9-10	7.2.2	77	9.2.2	43	Voids and Blisters
9.2.3	9-12	7.2.3	77	9.2.3	43	Breakdown
10	10-1	8	79	10	44	Laminate Conditions
10.1	10-1	8.1	80	10.1	44	Introduction
10.1.1	10-2			10.1.1	44	Identification of Defects
10.2	10-3			10.2	44	Laminate Damage
10.2.1	10-3	8.2.1	81	10.2.1	44	Measling and Cracking
10.2.2	10-5	8.2.3	82	10.2.2	45	Blistering and Delamination
10.2.3	10-8	8.2.4	83	10.2.3	45	Weave Texture/Weave Exposure
10.2.4	10-9	8.2.6	84	10.2.4	45	Haloing and Edge Delamination
10.2.5	10-11	8.2.7	85	10.2.5	46	Pink Ring
10.3	10-12			10.3	46	Flexible and Rigid-Flex Printed Wiring
10.4	10-14			10.4	47	Solder Resist Discoloration
10.5	10-15	8.2.8	85	10.5	47	Burns
10.6	10-16	8.3	86	10.6	47	Bow and Twist
10.7	10-17			10.7	47	Conductor/Land Damage
10.7.1	10-17			10.7.1	47	Reduction in Cross-Sectional Area
10.7.2	10-18			10.7.2	48	Lifted Pads/Lands
11	11-1	9	87	11	49	Discrete Wiring
11.1	11-2	9.1	88	11.1	49	Solderless Wrap
11.1.1	11-3	9.1.1	88	11.1.1	49	Number of Turns

IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
11.1.2	11-14	9.1.2	89	11.1.2	50	Turn Spacing
11.1.3	11-5	9.1.3	90	11.1.3	50	End Tails, Insulation Wrap
11.1.4	11-7	9.1.4	91	11.1.4	50	Raised Turns Overlap
11.1.5	11-8	9.1.5	92	11.1.5	50	Connection Position
11.1.6	11-10	9.1.6	93	11.1.6	50	Wire Dress
11.1.7	11-11	9.1.7	93	11.1.7	50	Wire Slack
11.1.8	11-12	9.1.8	94	11.1.8	50	Plating
11.1.9	11-13	9.1.9	94	11.1.9	50	Damaged Insulation & Terminals
11.1.10	11-14	9.1.9	95	11.1.10	50	Conductor Damage
11.2	11-15	9.3	98	11.2	50	Jumper Wires
11.2.1	11-16	9.3.1	99	11.2.1	50	Wire Selection
11.2.2	11-17	9.3.2	99	11.2.2	50	Wire Routing
11.2.2.1	11-18			11.2.2.1	50	Component Side
11.2.2.2	11-19			11.2.2.2	50	PTH Termination Side
11.2.3	11-20	9.3.3	101	11.2.3	50	Wire Staking
11.2.4	11-22	9.3.4	102	11.2.4	51	Plated-Through Holes
11.2.4.1	11-23			11.2.4.1	51	Lead in Hole
11.2.4.2	11-24			11.2.4.2	51	Wrapped Attachment
11.2.4.3	11-25			11.2.4.3	51	Lap Soldered
11.2.5	11-26	9.3.5	103	11.2.5	51	SMT
11.2.5.1	11-26			11.2.5.1	51	Chip and Cylindrical End Cap Components
11.2.5.2	11-27			11.2.5.2	51	Gull Wing
11.2.5.3	11-28			11.2.5.3	51	J-Lead
11.2.5.4	11-28			11.2.5.4	51	Vacant Land/Pad
12	12-1	10	105	12	52	Surface Mount Assemblies
				12.0.1	52	Guidelines for Placement of SMT Components
				12.0.1.1	52	Small Devices Incorporating Two Terminations
				12.0.1.2	52	Mounting of Cylindrical End Cap (MELF) Devices
				12.0.1.3	52	Registration of Castellated Chip Carriers
				12.0.1.4	52	Surface Mounted Device Lead and Land Contact
				12.0.1.5	52	Surface Mounted Device Lead Side Overhang
				12.0.1.6	52	Surface Mounted Device Lead Toe Overhang
				12.0.1.7	52	Surface Mounted Device Lead Heel Clearance
				12.0.1.8	52	Surface Mounted Device Lead Height Off Land (Prior to Soldering)
				12.0.1.9	53	Positioning of "J" Ledged Devices
				12.0.1.10	53	Positioning Gull-Wing Ledged Devices
				12.0.1.11	53	Other Devices
12.1	12-3	10.1	106	12.1	53	Staking Adhesive
12.2	12-5	10.2	107	12.2	53	Solder Joints
12.2.1	12-5	10.2.1	107	12.2.1	53	Chip Components - Bottom Only Terminations
12.2.1.1	12-6			12.2.1.1	53	Side Overhang (A)
12.2.1.2	12-7			12.2.1.2	53	End Overhang (B)
12.2.1.3	12-8			12.2.1.3	53	End Joint Width (C)
12.2.1.4	12-9			12.2.1.4	53	Side Joint Length (D)
12.2.1.5	12-10			12.2.1.5	53	Maximum Fillet Height (E)
12.2.1.6	12-1			12.2.1.6	53	Minimum Fillet Height (F)

IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
12.2.1.7	12-11			12.2.1.7	54	Solder Thickness (G)
12.2.2	12-12	10.2.2	109	12.2.2	54	Chip Components - Rectangular or Square End Components - 1, 3, or 5 Side Termination
12.2.2.1	12-13			12.2.2.1	54	Side Overhang (A)
12.2.2.2	12-15			12.2.2.2	54	End Overhang (B)
12.2.2.3	12-16			12.2.2.3	54	End Joint Width (C)
12.2.2.4	12-18			12.2.2.4	54	Side Joint Length (D)
12.2.2.5	12-19			12.2.2.5	54	Maximum Fillet Height (E)
12.2.2.6	12-20			12.2.2.6	54	Minimum Fillet Height (F)
12.2.2.7	12-21			12.2.2.7	54	Solder Thickness (G)
12.2.2.8	12-22			12.2.2.8	54	End Overlap (J)
12.2.3	12-23	10.2.3	112	12.2.3	55	Cylindrical End Cap Termination
12.2.3.1	12-24			12.2.3.1	55	Side Overhang (A)
12.2.3.2	12-25			12.2.3.2	55	End Overhang (B)
12.2.3.3	12-26			12.2.3.3	55	End Joint Width (C)
12.2.3.4	12-27			12.2.3.4	55	Side Joint Length (D)
12.2.3.5	12-28			12.2.3.5	55	Maximum Fillet Height (E)
12.2.3.6	12-29			12.2.3.6	55	Minimum Fillet Height (F)
12.2.3.7	12-30			12.2.3.7	55	Solder Thickness (G)
12.2.3.8	12-31			12.2.3.8	55	End Overlap (J)
12.2.4	12-32	10.2.4	115	12.2.4	56	Leadless Chip Carriers with Castellated Terminations
12.2.4.1	12-33			12.2.4.1	56	Side Overhang (A)
12.2.4.2	12-34			12.2.4.2	56	End Overhang (B)
12.2.4.3	12-35			12.2.4.3	56	Minimum End Joint Width (C)
12.2.4.4	12-36			12.2.4.4	56	Minimum Side Joint Length (D)
12.2.4.5	12-37			12.2.4.5	56	Maximum Fillet Height (E)
12.2.4.6	12-37			12.2.4.6	56	Minimum Fillet Height (F)
12.2.4.7	12-38			12.2.4.7	56	Solder Thickness (G)
12.2.5	12-39	10.2.5	118	12.2.5	56	Flat Ribbon L and Gull Wing Leads
12.2.5.1	12-39			12.2.5.1	56	Side Overhang (A)
12.2.5.2	12-43			12.2.5.2	56	Toe Overhang (B)
12.2.5.3	12-44			12.2.5.3	56	Minimum End Joint Width (C)
12.2.5.4	12-46			12.2.5.4	57	Minimum Side Joint Length (D)
12.2.5.5	12-47			12.2.5.5	57	Maximum Heel Fillet Height (E)
12.2.5.6	12-48			12.2.5.6	57	Minimum Fillet Height (F)
12.2.5.7	12-50			12.2.5.7	57	Solder Thickness (G)
12.2.6	12-51	10.2.6	121	12.2.6	57	Round or Flattened (Coined Leads)
12.2.6.1	12-51			12.2.6.1	58	Side Overhang (A)
12.2.6.2	12-52			12.2.6.2	52	Toe Overhang (B)
12.2.6.3	12-52			12.2.6.3	52	Minimum End Joint Width (C)
12.2.6.4	12-53			12.2.6.4	52	Minimum Side Joint Width (D)
12.2.6.5	12-54			12.2.6.5	52	Maximum Heel Fillet Height (E)
12.2.6.6	12-55			12.2.6.6	52	Minimum Heel Fillet Height (F)
12.2.6.7	12-56			12.2.6.7	52	Solder Thickness (G)
12.2.6.8	12-56			12.2.6.8	52	Minimum Side Joint Height (Q)
12.2.7	12-57	10.2.7	124	12.2.7	52	J-Leads
12.2.7.1	12-57			12.2.7.1	52	Side Overhang (A)
12.2.7.2	12-59			12.2.7.2	58	Toe Overhang (B)

IPC-A-610C	Page	IPC-A-610B	Page	HDBK-610	Page	Topic
12.2.7.3	12-60			12.2.7.3	58	End Joint Width (C)
12.2.7.4	12-61			12.2.7.4	58	Side Joint Length (D)
12.2.7.5	12-62			12.2.7.5	59	Maximum Fillet Height (E)
12.2.7.6	12-63			12.2.7.6	59	Minimum Heel Fillet Height (F)
12.2.7.7	12-65			12.2.7.7	59	Minimum Solder Thickness (G)
12.2.8	12-66	10.2.8	127	12.2.8	59	Butt/I Joints
12.2.8.1	12-66			12.2.8.1	59	Maximum Side Overhang (A)
12.2.8.2	12-67			12.2.8.2	59	Maximum Toe Overhang (B)
12.2.8.3	12-67			12.2.8.3	59	Minimum End Joint Width (C)
12.2.8.4	12-68			12.2.8.4	59	Minimum Side Joint Length (D)
12.2.8.5	12-68			12.2.8.5	59	Maximum Fillet Height (E)
12.2.8.6	12-69			12.2.8.6	59	Minimum Fillet Height (F)
12.2.8.7	12-69			12.2.8.7	59	Solder Thickness (G)
12.2.9	12-70			12.2.9	59	Flat Lug Leads
12.2.10	12-71			12.2.10	59	Tall Profile Components Having Bottom Only Terminations
12.2.11	12-72			12.2.11	59	Inward Formed L-Shaped Ribbon Leads
12.2.12	12-74			12.2.12	59	Area Array/Ball Grid Array
12.3	12-77	10.3	129	12.3	60	Chip Component - Termination Variations
				12.3.0.1	60	Chip Components - Termination Variations - Three or Five Side Terminations - Stacking
12.3.1	12-77			12.3.1	60	Chip Components - Termination Variations Three or Five Side Terminations - Mounting on Side
12.3.2	12-78			12.3.2	60	Deposited Electrical Elements - Mounting Upside Down
12.4	12-79	10.3	129	12.4	60	SMT Soldering Anomalies
12.4.1	12-79			12.4.1	60	Tombstoning
12.4.2	12-80			12.4.2	60	Coplanarity
12.4.3	12-81			12.4.3	60	Reflow of Solder Paste
12.4.4	12-82			12.4.4	60	Nonwetting
12.4.5	12-83			12.4.5	61	Dewetting
12.4.6	12-84			12.4.6	61	Disturbed Solder
12.4.7	12-85			12.4.7	61	Fractured Solder
12.4.8	12-86			12.4.8	61	Pinholes/Blowholes
12.4.9	12-87			12.4.9	61	Bridging
12.4.10	12-88		129	12.4.10	61	Solder Balls/Solder Fines
12.4.11	12-89		129	12.4.11	62	Solder Webbing
12.5	12-90	10.4	130	12.5	62	Component Damage
12.5.1	12-90	10.4.1.1	131	12.5.1	62	Cracks and Chip-Outs
12.5.2	12-93	10.4.1.2		12.5.2	62	Metallization
12.5.3	12-94	10.4.2.1		12.5.3	62	Leaching
Appendix A					63	Electrical Conductor Spacing Appendix A
				Appendix B	65	Metric Conversion Information, Appendix H-1
				Appendix C	70	Comparison of IPC-A-610 Revision B to C
				Appendix D	84	U.S. Department of Defense Adoption Notice
				Misc.	1	IPC-A-610C Amendment 1

Handbook and Guide to IPC-A-610 (Includes IPC-A-610B to C Comparison)

1 ACCEPTABILITY OF ELECTRONIC ASSEMBLIES

1.0.1 Preamble/Foreword This handbook is a companion reference to and was prepared using IPC-A-610C and IPC-A-610C Amendment 1. The amendment provides additional criteria and clarification statements. The amendment is included with this handbook following Appendix C and can be downloaded at no cost from the IPC website at the following link:

www.ipc.org/html/610C%2BAmdendment.pdf

Electrical Conductor Spacing that is provided in IPC-A-610C Appendix A has been incorporated into the text of this handbook and is also included as Appendix A to this handbook.

Information on metric conversion is provided as Appendix B.

An expanded subject matter based cross-reference of the two versions is provided in Appendix C.

A copy of the IPC-A-610 Department of Defense Adoption Notice is provided as Appendix D.

The intent of this handbook is to explain the technical rationale for selected Acceptability, Process Indicator and Defect criteria and to provide information regarding assembly technology. Additional information is provided to give a broader understanding of the process considerations needed for the production of acceptable hardware.

Note: Not all information provided in IPC-A-610C is addressed in this handbook.

While IPC-T-50 establishes unique definitions for the acronyms PCB, PWB, PCA and PWA, the term PCB (printed circuit board) is used generically in this handbook.

1.0.2 Format of this Handbook The section and paragraph numbers in this handbook refer and correspond to the section and paragraph numbers in Revision C of IPC-A-610. Where used verbatim, text of IPC-A-610C is identified by being boxed.

For the purposes of the handbook, a capitalized “Standard” in the handbook text refers to IPC-A-610C. It should also be noted that any references in the handbook text (not text taken from the Standard) refer to sections, tables, and figures in the handbook; see Example 1. References in the handbook text to sections, tables, and figures in the Standard will be followed by “of the Standard”; see Example 2.

Example 1:

4.4.2 For more information on adhesive on areas to be soldered see 12.1 on page 12-3 of the Standard.

Example 2:

9.1.2 For more information on magnification power for inspection see Table 1-2 of the Standard.

Text excerpted from documents other than IPC-A-610 is shown in **BOLD SMALL CAPS** to assist with clarity.

1.0.3 Supplemental Definitions These supplemental definitions are provided to assist the reader in understanding the intent of portions of the text of the Standard. Terms used in the Standard or this Handbook and not otherwise defined are defined as follows. Definitions from IPC-T-50 are identified with *.

Barely/slight – By a very little, almost not discernable/measurable/perceptible.

Clearly – Free from anything that dims, obscures or inhibits observation. Easily discernable to the eye.

Coefficient of Thermal Expansion – The CTE is the amount that a material (component, PWB laminate, etc.) changes dimension as a result of temperature change. The CTE is expressed in parts per million per degree Celsius (p/m/C°). The CTE differential that exists between the component and the PWB is a factor in determining the reliability of the assembly. If a ceramic surface mount component that has a CTE of 6p/m/C° is placed on a laminate material such as FR-4 that has a CTE of 14 - 16 p/m/C°, the designer needs to assure that compliance of the component leads is sufficient to accommodate the differential in CTE. The coefficient of thermal expansion (CTE) is sometimes also referred to as the Thermal Coefficient of Expansion (TCE). In this Handbook the term CTE is used.

Disposition – A final settlement. The act of identifying the action to be taken on a Defect.

Minimum Electrical Clearance (Minimum Electrical Spacing)* – The minimum allowable distance between adjacent conductors, at a given voltage and altitude, that is sufficient to prevent dielectric breakdown, corona, or both from occurring between the conductors. Minimum electrical clearance is a value determined by the designer and is based on multiple factors.

Pitch – The nominal center-to-center distance of adjacent conductors. When the conductors are of equal size and their spacing is uniform, the pitch is usually given in mils.

the reference edge of the adjacent conductors, as illustrated in Figure 1-1.

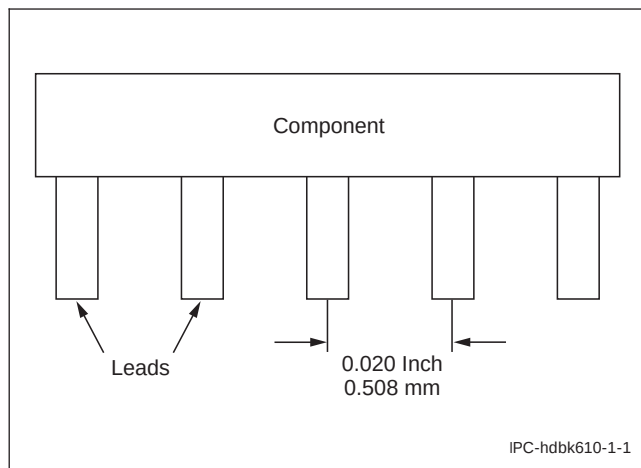


Figure 1-1 Pitch

When referring to a device as being a “20 mil pitch component” that means that the leads are 0.020 inch apart measured center-to-center.

Repair* – The act of restoring the functional capability of a defective article in a manner that precludes compliance of the article with applicable drawings or specifications.

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

Scrap – In some cases the cost to repair an assembly exceeds the cost to replace it with a like item or may cause the assembly to be unreliable. In such cases the defective assembly is usually dispositioned as Scrap.

Use-As-Is – Products containing defects that do not impact performance may sometimes be dispositioned Use-As-Is. For instance, loss of date code part marking on a finished assembly is a Defect, but not a Defect that affects the performance of the product. Such a Defect could be dispositioned Use-As-Is. The disposition Use-As-Is may require approval of the customer/user.

1.0.4 Background on IPC-A-610 Revision C The Standard is an industry consensus document published by IPC. The technical content and criteria of any amendments or revisions to the IPC-A-610 were developed by the collective efforts of the IPC Task Group 7-31b under the 7-30 Product Assurance Committee. This Task Group is comprised of individuals from a wide sector of the electronics manufacturing community. IPC-A-610 is currently in its “C” Revision meaning it has been revised three times since its initial release.

1.1 Scope

1.1 Scope

This standard is a collection of visual quality acceptability requirements for electronic assemblies. It was prepared by the Product Assurance Committee of the IPC.

This document presents acceptance requirements for the manufacture of electrical and electronic assemblies. Historically, electronic assembly standards contained a more comprehensive tutorial addressing principles and techniques. For a more complete understanding of this document’s recommendations and requirements, one may use this document in conjunction with IPC-HDBK-001 and J-STD-001.

IPC-A-610 has criteria outside the scope of J-STD-001 defining handling, mechanical and other workmanship requirements. Table 1-1 is a summary of related documents.

The Standard provides visual characteristics of products with criteria that can be applied without making physical measurements to the electronic assembly to determine final acceptability (unless for referee purposes); see 1.4.3 regarding the relationship between the IPC-A-610 and the J-STD-001.

1.2 Purpose

1.2 Purpose

The visual standards in this document reflect the requirements of existing IPC and other applicable specifications.

In order for the user to apply and use the content of this document, the assembly/product should comply with other existing IPC requirements, such as IPC-SM-782, IPC-2221, IPC-6011 and IPC-A-600. If the assembly does not comply with these or equivalent requirements, then the acceptance criteria needs to be defined between the customer and supplier.

The illustrations in this document portray specific points noted in the title of each page. A brief description follows each illustration. It is not the intent of this document to exclude any Acceptable procedure for component placement or for applying flux and solder used to make the electrical connection; however, the methods used must produce completed solder joints conforming to the acceptability requirements described in this document.

In the case of a discrepancy, the description or written criteria always takes precedence over the illustrations.

Existing IPC and applicable industry specifications have been selected to reflect Best Manufacturing Practices.

The intent is not to require the use of the Standards listed by Table 1-1, but rather to advise or warn users of IPC-A-610C that unless acceptable guidelines and requirements are used in the design of equipment, the acceptability criteria depicted by the Standard may not be achievable. For example, if a design standard other than IPC-2221 was used to design a SMT printed wiring board assembly, the

is no assurance that the ratio of component footprint to termination area defined by the alternative design criteria would result in an interface that would allow the heel fillet criteria of the Standard to be achieved. If alternative or unique design criteria are used then the User and the Supplier (Assembler) should agree on appropriate acceptance criteria.

IPC-A-610 defines the visual acceptance criteria for various attributes and does not address the processes or procedures required for the assembly of electronic equipment. Any process that produces hardware that complies with the acceptability criteria of IPC-A-610 is acceptable, unless other applicable requirements (contract, master drawing, approved assembly drawing, etc.) define or specify the process(es) to be used. Other standards, such as EIA/IPC J-STD-001, should be consulted for information on process control, frequency of inspection and type of inspection (100% or Sample Inspection).

The written criteria **always** take precedence over illustrations in the Standard. Both courts and industry experts have held that when observing a drawing, figure or photograph, each viewer sees something slightly different. Such differences may be caused by anomalies in color vision, subtle prejudices, etc. Therefore, acceptability decisions must be made based on the written criteria for each attribute.

1.3 Specialized Designs

1.3 Specialized Designs

IPC-A-610, as an industry consensus document, cannot address all of the possible components and product design combinations. However, the standard does provide criteria for commonly used technologies. Where uncommon or specialized components or technologies are necessary, good judgment should be used while applying the criteria of this standard. However, where similar characteristics exist, this document may provide guidance for product acceptance criteria. Often, unique definition is necessary to consider the specialized characteristics while considering product performance criteria. The development should include customer involvement or consent and the criteria should include agreed definition of product acceptance.

Whenever possible this criteria should be submitted to the IPC Technical Committee to be considered for inclusion in upcoming revisions of this standard.

It wasn't possible to include all possible design considerations in the Standard.

With the use of good judgement, acceptability criteria of the Standard may be adopted for uncommon technologies.

The user should approve acceptability criteria developed for unique designs or assembly procedures.

1.4 Terms & Definitions

1.4 Terms & Definitions

Items noted with an * are quoted from IPC-T-50, "Terms and Definitions for Interconnecting and Packaging Electronic Circuits."

IPC documents, including the Standard and this Handbook, depend on IPC-T-50 for the definitions of common terms. Where special definitions need to be established, each document establishes those definitions individually. Definitions listed in 1.4 through 1.4.8 of the Standard are supplemental to the definitions provided by IPC-T-50. This Handbook provides additional definitions of terms used in the Standard.

1.4.1 Classification

1.4.1 Classification

Criteria defined in this document reflect three classes, which are as follows:

Class 1 - General Electronic Products

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

Class 2 - Dedicated Service Electronic Products

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

Class 3 - High Performance Electronic Products

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

Product Class definitions are consistent throughout IPC Standards. The descriptions of product classes are intentionally general due to the wide variety of products that may be assembled using the requirements of the Standard.

Users and manufacturers need to agree on the Product Class; see 1.4.2. The Product Class should be determined based on the end-use environment and criticality of functional availability of the end product.

1.4.2 Establishing Conformance Class

1.4.2 Establishing Conformance Class

The customer has the ultimate responsibility for identifying the class to which his assembly is evaluated.

Thus, accept and/or reject decisions must be based on applicable documentation such as contracts, drawings, specifications, standards and reference documents.

Paragraph 1.4.2 applies to products specified by the user or products where the user owns the design package. In cases where a manufacturer owns the design package, and/or produces a product to their own specifications, the manufacturer is responsible for defining the Product Class. For example, if Company A produces a product and then stocks that product as an Off-the-Shelf (OTS) item for sale to a user, Company A has the responsibility to define the product class.

Evaluation of each product must be performed based on the Product Class as defined by the applicable document. Each person involved in the inspection or evaluation of products must be provided information regarding the product Class applicable to the evaluation/inspection. The inspection/evaluation personnel never determine the product class.

1.4.3 Acceptance Criteria

1.4.3 Acceptance Criteria

When IPC-A-610 is cited or required by contract as a stand-alone document for inspection and/or acceptance, the requirements of J-STD-001 "Requirements for Soldered Electrical and Electronic Assemblies" do not apply (unless separately and specifically required).

In the event of conflict, the following order of precedence applies:

1. Procurement as agreed and documented between customer and vendor.
2. Master drawing or master assembly drawing reflecting the customers detailed requirements.
3. When invoked by the customer or per contractual agreement, IPC-A-610.
4. Other documents to extent specified by the customer.

The user (customer) has the responsibility to specify acceptance criteria. If no criteria is specified, required, or cited, then best manufacturing practice applies. When J-STD-001 and IPC-A-610 or other related documents are cited, the order of precedence is to be defined in the procurement documents.

Criteria are given for each class in four levels of acceptance: Target Condition, Acceptable Condition, and either Defect Condition or Process Indicator Condition.

When IPC-A-610 is required, process control and other assembly criteria of J-STD-001 do not apply to assembly of the product unless separately and specifically required

by contract or drawing. When J-STD-001 is invoked, IPC-A-610 is not invoked as a mandatory document unless otherwise mandated in the contract.

The procurement documents, contracts, and purchase orders are the most important documents associated with a business transaction. These documents are used to specify special features, unusual performance or assembly requirements and take precedence over any other documentation associated with the transaction.

A master drawing includes specially selected assembly procedures, materials, or other criteria that are essential to satisfactory performance of the product. Procedures, materials and other criteria included on the master drawing supercede the requirements of IPC-A-610.

IPC-A-610 is based on Industry consensus and Best Manufacturing Practices. When no specialized criteria are required by procurement documents or the Master Drawing, the acceptability criteria of IPC-A-610 should be applied.

When both J-STD-001 and IPC-A-610 are required, the text of the procurement document should clearly identify which document takes precedence. For example: "Product XYZ shall be built in accordance with J-STD-001 and IPC-A-610" could cause conflicts. "Product XYZ shall be assembled in accordance with the procedures and processes of the specified class requirements of J-STD-001 and meet the acceptability criteria of the specified class requirements of IPC-A-610" eliminates the conflicts; see 1.4.1 for additional information for class requirements.

1.4.3.1 Target Condition

1.4.3.1 Target Condition

A condition that is close to perfect and in the past has been labeled as "preferred"; however, it is a desirable condition and not always achievable and may not be necessary to ensure reliability of the assembly in its service environment.

The "target condition" should be the goal of all assembly activity. Automated processes like machining, cleaning, component placement, etc. can continuously meet the target condition more so than the same processes done manually. Both automated and hand assembly can achieve the target condition, but manual assembly provides greater variation from the target.

1.4.3.2 Acceptable Condition

1.4.3.2 Acceptable Condition

This characteristic indicates a condition that, while not necessarily perfect, will maintain the integrity and reliability of the assembly in its service environment. Acceptable can be slightly better than the minimum end product requirements to allow for shifts in the process.

The “acceptable condition” is a condition that meets the design requirements (product integrity, form, fit, function, performance and reliability) of the product when used as the design intended. An acceptable condition can be slightly better or slightly worse than the target condition. For example, the amount of solder on a connection has a target, the perfect amount of solder. The acceptable connection can have much less solder or much more solder than the target amount, yet still satisfy the performance and reliability requirements for the product.

1.4.3.3 Defect Condition

1.4.3.3 Defect Condition

A Defect is a condition that may be insufficient to ensure the form, fit or function of the assembly in its end use environment. Defect conditions will be dispositioned based on design, service, and customer requirements. Disposition may be to rework, repair, scrap, or use-as-is. “Use-As-Is” may require customer concurrence.

Use of the word “may” instead of “will” emphasizes that not all defects are created equal. A defect, by definition, does not meet the acceptability criteria of IPC-A-610, but may NOT negatively impact the functional capability or design performance of the product. For example, failure to comply with the Clarity of Marking requirement of 8.3 is a defect, but may not affect the form, fit, function, performance or reliability of the product.

If a defect is identified, it must be dispositioned. To “disposition” a defect means to decide what to do with it. Dispositions, or options/alternatives, usually include rework, repair, scrap or “use-as-is.”

A disposition to rework can usually be implemented without customer approval. A disposition to repair may require the customer’s approval, or the customer may have the option to review and approve the proposed repair procedure. Reworking or repairing a product simply because it does not exhibit the target condition described in the Standard does not necessarily result in a more reliable product, and may actually induce premature failure. Excessive or unnecessary rework can damage parts, the printed wiring substrate, or internal connections of PTHs and vias. It can also impact on schedules and profitability. A disposition of “use-as-is” may also require customer approval.

After a defect is documented, the defect information should be used to assure that appropriate process corrective action can be taken to prevent recurrence of the defect. Effective corrective action systems usually begin with documenting the discrepancy and identifying the discrepant hardware. The discrepancy is then evaluated against the process and end product requirements to determine if the product is useable, requires rework, or cannot be used. If the fault is attributable to the manufacturer’s internal processes, corrective action to eliminate the cause is usually prescribed.

Where faults are attributable to external causes, such as purchased parts or assemblies, the supplier is usually asked to provide root cause analysis and corrective action. All actions in the corrective action system should be recorded for reference. A formal process control and continuous improvement plan may include documented historical data that is available for review. Trends and overall activity levels are typically monitored to allow management of the procurement and assembly processes. Additional information on rework and repair can be found in IPC-7711 and IPC-7721.

After solder removal, the device is removed, another is inserted in the hole, and the leads are soldered. Removal of SMDs with manual tools is typically done using special soldering iron tips, “heated” tweezers, or small area hot air wands. On multi-leaded SMDs and chip devices, these tips are often formed into a “U” to allow for heating of both sides of the part. This design allows for simultaneous reflow of all terminations (helping in the removal of the part) and minimizes damage to the device (by evenly heating from both sides). Similar arrangements are made for four-sided “quad” packages using a soldering iron with a collet that heats on all four sides of the device at once. Semi-automated or automated hot air systems are also used for desoldering of SMDs. These devices use heated air or nitrogen gas and may incorporate pick-and-place systems with thermocouple-controlled hot gas heaters and a computer interface to record and “replay” successful solder schedules.

1.4.3.4 Process Indicator Condition

1.4.3.4 Process Indicator Condition

A Process Indicator is a condition (not a defect) which identifies a characteristic that does not affect the “form, fit or function” of a product. Such condition is a result of material, design and/or operator/machine related causes that create a condition that neither fully meets the acceptance criteria nor is a Defect.

A process indicator is, by definition, a condition that does not fully comply with the acceptability criteria, but does not affect the form, fit, function, reliability or performance of the product. Process indicators might include a wire that has insufficient stress relief on a Class 2 product, or a component that is mounted with the meniscus in the plated through hole in a Class 3 product.

1.4.3.4 continued

Process Indicators should be monitored as part of the process control system and when the number of Process Indicators indicate abnormal variation in the process or identify an undesirable trend, then the process should be analyzed. This may result in action to reduce the variation and improve yields.



A process indicator signals that the assembly process may be going out of control. A process should not be adjusted until a sufficient number of process indicators have been noted to clearly define the need for a process adjustment.

1.4.3.4 continued

Disposition of individual Process Indicators is not required and affected products should be used as is.

Although process indicators are typically documented as part of a process control system, the Standard does not require that process indicators be documented or dispositioned. Only a defect must be dispositioned per the Standard.

1.4.3.4 continued

Process control methodologies are to be used in the planning, implementation and evaluation of the manufacturing processes used to produce soldered electrical and electronic assemblies. The philosophy, implementation strategies, tools and techniques may be applied in different sequences depending on the specific company, operation, or variable under consideration to relate process control and capability to end product requirements. The manufacturer needs to maintain objective evidence of a current process control/continuous improvement plan that is available for review.

The statement above is a recommendation, or statement of intent, applicable to the use of Best Manufacturing Practices (BMP) in the assembly of all Product Classes, and should not be understood to specify a requirement for the assembly of products using process control procedures. Figure 1-2 provides a graphic example of acceptability.

1.4.3.5 Conditions Not Specified

1.4.3.5 Conditions Not Specified

Conditions that are not otherwise specified as Defective or as a Process Indicator are considered Acceptable unless it can be established that the condition affects end user defined form, fit or function.

This statement has two meanings.

- When no criteria for a specific condition is provided in this Standard, nonconformance needs to be determined by the supplier and may require agreement with the end user; see 1.3 for additional information.
- When the Standard states a specific acceptable criterion but does not provide a corresponding defect criterion, nonconformance needs to be determined by the supplier and may require agreement with the end user.

This handbook was prepared using IPC-A-610C and IPC-A-610C Amendment 1. The amendment provides additional criteria and clarification.

1.4.4 Board Orientation

1.4.4 Board Orientation

The following terms are used throughout this document to determine the board side.

Terms need to be correctly applied for the assembly to meet the intended acceptability criteria. Certain acceptability criteria of the Standard, including that stated in Table 6-2, are dependent on attributes visible from either the primary or secondary side of the printed wiring assembly (PWA).

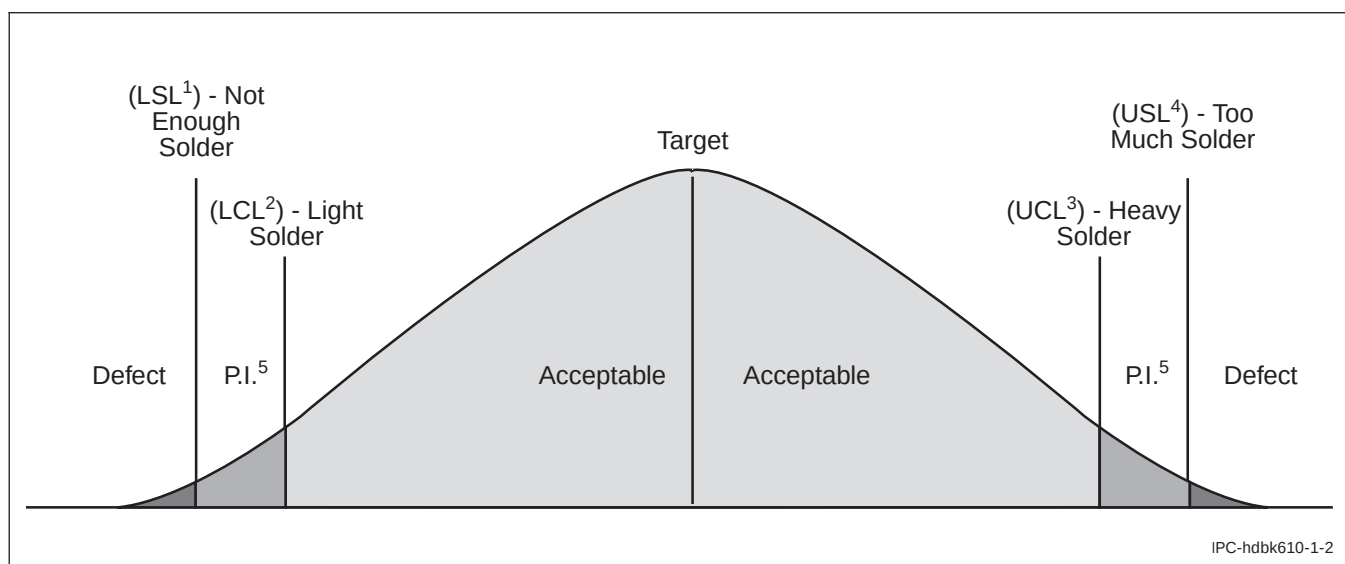


Figure 1-2 Graphic Example of Acceptability

1. LSL - Lower Spec Limit 3. UCL - Upper Control Limit 5. P.I. - Process Indicator
2. LCL - Lower Control Limit 4. USL - Upper Spec Limit

1.4.4.1 *Primary Side(s)**1.4.4.1 *Primary Side(s)**

That side of a packaging and interconnecting structure (PWB) that is so defined on the master drawing. (It is usually the side that contains the most complex or the most number of components. This side is sometimes referred to as the component side or solder destination side in through-hole mounting technology.)

Typically the side with the most components. Usually the primary side is inspected for component mounting, lead forming, and topside solder fillet. It is sometimes referred to as the “destination side” because when machine soldering with a wave solder system, the solder is applied from the bottom (secondary) side of the PWA, hence the top side of the PWA is the destination for the solder.

1.4.4.2 *Secondary Side(s)**1.4.4.2 *Secondary Side(s)**

That side of a packaging and interconnecting structure (PWB) that is opposite the primary side. (This side is sometimes referred to as the solder side or solder source side in through-hole mounting technology.)

The side with the smallest number of components. Usually the secondary side is inspected for lead clinch and solder connection integrity. It is sometimes referred to as the “solder source side” because when machine soldering with a wave solder system the solder is applied from the bottom (secondary) side of the PWA, hence the bottom side of the PWA is the source for the solder.

1.4.4.3 Solder Source Side**1.4.4.3 Solder Source Side**

The solder source side is that side of the PWB to which solder is applied. The solder source side is normally the secondary side of the PWB when wave, dip, or drag soldering are used. The solder source side may be the primary side of the PWB when hand soldering operations are conducted. The source/destination side must be considered when applying some criteria, such as that in Table 6-2.

Usually considered the side with the fewest components; see 1.4.4.2.

1.4.4.4 Solder Destination Side**1.4.4.4 Solder Destination Side**

The solder destination side is that side of the PWB that the solder flows toward. The destination is normally the primary side of the PWB when wave, dip or drag soldering are used. The destination side may be the secondary side of the PWB when hand-soldering operations are conducted. The source/destination side must be considered when applying some criteria, such as that in Table 6-2.

Usually considered the side with the most components; see 1.4.4.1.

1.4.5 Electrical Clearance**1.4.5 Electrical Clearance**

The minimum spacing between noncommon uninsulated conductors (e.g., patterns, materials, hardware, residue) is referred to as “minimum electrical clearance” throughout this document and is defined in the applicable design standard or on the approved or controlled documentation. Insulating material must provide sufficient electrical isolation. In the absence of a known design standard use Appendix A (derived from IPC-2221).

1.4.5 IPC-A-610C Amendment 1

Any violation of minimum electrical clearance as a result of nonconformance to defined criteria of IPC-A-610 is a defect condition.

Minimum electrical clearance is a design value that defines the minimum distance two conductors must be physically separated to prevent shorting or arcing from one conductor to the other. The term “minimum electrical clearance,” used frequently in the Standard, is defined by the designer of the PWA. It is frequently included on the master drawing or detail assembly drawing. In the event that a dimensional requirement for minimum electrical clearance is not specified, the dimensions in columns A5, A6, and A7 of Table 6-1 in Appendix A of the Standard should be used when evaluating PWAs. In many cases, the voltages on the circuit assemblies being assembled are not known. In these cases, the customer, or owner of the design, should be contacted to determine the appropriate voltage level of Table 6-1 in Appendix A of the Standard. Non-common conductors also includes items such as mounting brackets, chassis, adjacent boards, etc.

When using the criteria of IPC-2221 Table 6-1 to evaluate minimum conductor spacing (minimum electrical clearance), caution should be exercised to assure that columns A5, A6, or A7 (as appropriate to the operating environment) are used to evaluate printed wiring assemblies (PWAs). Columns B1, B2, and B3 should be applied only to bare board dimensions.

The criteria of IPC-2221 Table 6-1 may not be applicable to some radio frequency (RF) assemblies.

Amendment 1 added the statement regarding defect condition for any violation of minimum electrical clearance. This wasn't always obvious to users.

1.4.6 *Cold Solder Connection

1.4.6 *Cold Solder Connection

A solder connection that exhibits poor wetting and that is characterized by a grayish porous appearance. (This is due to excessive impurities in the solder, inadequate cleaning prior to soldering, and/or the insufficient application of heat during the soldering process.)

A connection in which the solder has not properly flowed and wetted the surface and the solder does not feather out on the connection elements. A cold solder joint is typically formed in hand solder operations, not mass soldering. A cold solder connection is a seldom seen, but extremely serious, defect where solder is usually not “wetted” to the connection elements, has poor grain structure and lacks the mechanical characteristics required to assure product reliability. Not all cold solder connections are characterized by a gray or porous appearance and may, upon casual observation, look simply like excess solder.

1.4.7 Leaching

1.4.7 *Leaching

The loss or removal of a basis metal or coating during a soldering operation.

Leaching occurs when the tin and lead in solder form a metallurgical reaction with the base metal of the solder connection elements. The metallurgical reaction reduces the thickness of the solderable surface coating on components, notably ceramic chip components and those ceramic components with thin depositions of solderable material. If molten solder is present for an extended period of time the leaching action can result in an electrical open circuit as the solderable surface is depleted.

1.4.8 Meniscus (Component)

1.4.8 Meniscus (Component)

Sealant or encapsulant on a lead, protruding from the seating plane of the component. This includes materials such as ceramic, epoxy or other composites, and flash from molded components.

A meniscus forms during the process of making the component body on a wide range of components. Figure 1-3 provides an example of meniscus on a component lead.

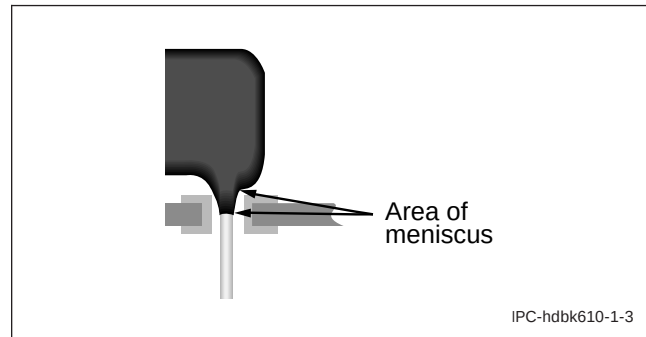


Figure 1-3 Meniscus on Component Lead

1.5 Examples and Illustrations

1.5 Examples and Illustrations

Many of the examples (illustrations) shown are grossly exaggerated to depict the reasons for this classification.

A Defect for Class 1 automatically implies a Defect for Class 2 and 3. A Defect for Class 2 implies a Defect for Class 3.

It is necessary that users of this standard pay particular attention to the subject of each section to avoid misinterpretation.

1.5.0.1 Graphic Aids Illustrations, drawings and photographs used in the Standard are exaggerated to clearly depict the condition being discussed. Photographs of target, acceptable, and defect conditions are representative examples of those conditions found in products produced by IPC member companies or otherwise made available to the IPC staff. See 1.2 for additional information on the advisability of using drawings, figures and photographs in making decisions on acceptability (decisions must be based on the text of the Standard, not the photograph, drawings or illustrations).

1.5.0.2 Flowdown of Requirements Users should recognize implied relationships exist throughout the Standard. Also note that a condition that is acceptable for Class 3 implies acceptability for both Class 1 and 2.

Instructors, operators and inspectors should be proficient in the tasks they are assigned. Some customers may require that objective evidence of that proficiency be maintained and available for review. Common examples of objective evidence are records of training to the applicable job performance, work experience, testing to the requirements of the Standard, and/or periodic reviews of performance.

1.5.0.3 Applying Appropriate Criteria Users of the Standard should exercise caution to assure that the criteria applied from the Standard are correctly selected. This is especially true when selecting criteria for unsupported holes and discrete wiring. Note that Revision C of IPC-A-610 includes expanded coverage for terminating leads in unsupported holes. Caution should be exercised to assure that the user selects the appropriate criteria for unsupported or supported holes. In some cases, Revision B of IPC-A-610 depicted solder when actually discussing component mounting or component lead forming. Confusion regarding the criteria in such cases is frequent. Similar criteria from a different section is not applicable unless specifically stated.

1.6 Inspection Methodology

1.6 Inspection Methodology

Accept and/or reject decisions must be based on applicable documentation such as contract, drawings, specifications and referenced documents.

The evaluation of a product needs to be performed in accordance with some established requirement. If the contract, the master drawing, or the detail assembly drawing defines no other requirement, then the assembly should be evaluated in accordance with the Standard.

1.6 continued

The inspector does not select the class for the assembly under inspection. Documentation that specifies the applicable class for the assembly under inspection is to be provided to the inspector.

The inspector must be advised of the product class of the assembly that they are inspecting; see 1.4.1.

1.6 continued

Automated Inspection Technology (AIT) is a viable alternative to visual inspection and complements automated test equipment. Many of the characteristics in this document can be inspected with an AIT system. IPC-AI-641 "User's Guidelines for Automated Solder Joint Inspection Systems" and IPC-AI-642 "User's Guidelines for Automated Inspection of Artwork, Inner-layers, and Unpopulated PWBs" provide more information on automated inspection technologies.

Automatic Inspection Technology (AIT) is a useful tool and is approved for use when inspecting products to the requirements of the Standard. However, AIT has limits and may not be able to evaluate all characteristics listed in the Standard.

1.6 continued

If the customer desires the use of industry standard requirements for frequency of inspection and acceptance, J-STD-001 is recommended for further soldering requirement details.

The Standard does not specify the frequency of inspections. The Standard also does not reference, or recommend, either sample-based inspection or 100% inspection. If information on sample-based inspection is desired, it is necessary to consult other sources for guidance. IPC-J-STD-001 or IPC-PC-9191 are recommended for such information.

1.7 Verification of Dimensions

1.7 Verification of Dimensions

The actual measurements provided in this document (i.e., specific part mounting and solder fillet dimensions and determination of percentages) are not required except for referee purposes.

The Standard does not require actual measurements to determine compliance. An inspector should be trained to recognize critical frequently used dimensions (0.5 mm, 1.0 mm or 0.020 inch, 0.040 inch, etc) without continuous reference to a standard of the same size. When disputes exist, it may be necessary to measure a dimension. Accurate measurement of solder fillet coverage and solder fillet dimensions are complex and time consuming and should be performed only in rare circumstances.

Commonly available materials may be used as visual reference material when inspecting products. For instance, comparing the diameter of 0.5 mm [0.020 in] wire solder to the fillet height is a good way to evaluate the end joint fillet on a chip component.

1.8 Magnification Aids and Lighting

1.8 Magnification Aids and Lighting

For visual inspection, some individual specifications may call for magnification aids for examining printed board assemblies. The tolerance for magnification aids is $\pm 15\%$ of the selected magnification power. Magnification aids used for inspection need to be appropriate with the item being processed. Lighting needs to be adequate for the magnification aids used. The magnification used to inspect solder connections is based on the minimum width of the land used for the device being inspected. When magnification is required by contract, the magnifications in Table 1-2 apply.

When magnification is required, the magnification power should be based on the size of the feature being inspected. Table 1-2 lists the magnification power for different feature sizes based on the width of circuit traces. Limitations of magnification power prevent over zealous inspection. The magnification power levels defined by Table 1-2 are considered sufficient to allow an inspector to positively identify characteristics and differentiate between a defect, process indicator, and acceptable condition.

A $1,000 \text{ lm/m}^2$ at the work surface is the accepted minimum level of illumination in which operators and inspectors should be expected to perform their tasks. $1,000 \text{ lm/m}^2$ is approximately equivalent to 100 foot-candles. Foot-candles and/or lumens per meter squared can be measured using a photographic light meter.

Usually inspection of small features suggests the need for increased light intensity. The type of light source used can play an important role in inspection. A light source that has

a color temperature of 3000°K (such as quartz halogen) provides a full color spectrum that is beneficial in identifying flux residue and other residual contaminants.

1.8 continued

Referee conditions are used to verify product rejected at the inspection magnification power. For assemblies with mixed land widths, the greater magnification may be used for the entire assembly.

Referee magnification power is intended to be used to identify the characterization of a previously identified questionable condition. If there is remaining uncertainty regarding whether a condition should be classified as a defect, or if additional visual information regarding what caused the defect can be gained, then the condition can be additionally evaluated using the referee magnification power of Table 1-2.

2 APPLICABLE DOCUMENTS

A listing of a document in this section does not mean that all of the document's requirements must be met. The extent to which the requirements of the referenced document must be followed depends on the text of the reference in the Standard. The purpose of the reference to other documents is informational only and no additional requirements are intended.

Example (Information only): From 1.6 of the Standard: Many of the characteristics in this document can be inspected with an AIT system. IPC-AI-641 "User's Guidelines for Automated Solder Joint Inspection Systems" and IPC-AI-642 "User's Guidelines for Automated Inspection of Artwork, Inner-layers, and Unpopulated PWBs" provide more information on automated inspection technologies.

This section advises the user of the Standard that an AIT system can be used for inspection, and that additional information can be found in either of the IPC documents referenced. None of the information presented in 1.6 of the Standard is intended as a firm requirement.

2.1 IPC Documents¹

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

Many definitions for the terms used in the Standard can be found in IPC-T-50.

IPC-CH-65 Guidelines for Cleaning of Printed Boards and Assemblies

The purpose of IPC-CH-65 is to serve as an updated, user-friendly road map for both fabrication and assembly cleaning. This handbook does not function as a highly detailed document for all areas. In areas of cleaning where recent detailed IPC manuals already exist, the relevant sections in IPC-CH-65 contain only sufficient information to make the reader reasonably knowledgeable. While the primary focus of this manual is fabrication and assembly cleaning, key related subjects are found in other sections. Modern cleaning cannot be properly discussed without also addressing the issues of worker safety and the environment.

IPC-A-600 Acceptability of Printed Boards

This document describes the preferred, acceptable, and nonconforming conditions that are either externally or internally observable on printed boards. This document discusses the visual interpretation of minimum requirements set forth in various printed board specifications, e.g.; IPC-6010 series, J-STD-003, etc. Most, if not all, of the

acceptability criteria for PCBs included in the Standard are drawn directly from IPC-A-600.

IPC-AI-641 User's Guidelines for Automated Solder Joint Inspection Systems

IPC-AI-642 User's Guidelines for Automated Inspection of Artwork, Inner-layers, and Unpopulated PCBs

IPC-TM-650 Test Methods Manual

2.4.22 Bow and Twist (Percentage)

2.4.28.1 Adhesion, Solder Resist (Mask), Tape Test Method

IPC-SM-782 Surface Mount Design Land Pattern Standard

IPC-CC-830 Qualification and Performance of electrical Insulating Compound for Printed Board Assemblies

IPC-2221 Generic Standard on Printed Board Design

IPC-6011 Generic Performance Specification for Printed Boards

IPC-7711 Rework of Electronic Assemblies

This document covers procedures for reworking electronic assemblies. It is a collection of information that describes the procedural requirements, tools, materials and methods to be used in the rework of electronic products. IPC-7711 is focused primarily on the removal and replacement of components. Although IPC-7711 is based in large part on the Product Class definitions of J-STD-001, it is applicable to most types of electronic equipment.

IPC-7721 Repair and Modification of Printed Boards and Electronic Assemblies

This document covers procedures for repairing and modifying electronic assemblies. It is a collection of information that describes the procedural requirements, tools and materials and methods to be used in the repair and modification of electronic products. IPC-7721 is focused primarily on the repair and modification of printed wiring boards and includes procedures for repair or replacement of printed circuit lands, conductors, termination areas, edge connectors and PTHs. Although IPC-7721 is based in large part on the Product Class definitions of J-STD-001, it is applicable to most types of electronic equipment.

2.2 Joint Industry Documents²

IPC/EIA J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

1. www.ipc.org

2. www.ipc.org

This standard prescribes practices and requirements for the manufacture of soldered electrical and electronic assemblies and relies heavily on process control methodology to ensure consistent quality levels during the manufacture of products. J-STD-001 is the document most closely related to the Standard.

IPC/EIA J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

Much of the acceptability criteria of the Standard deals with the condition of solder connections. The quality of a solder connection is dependent to a great degree on the solderability of the materials being soldered. J-STD-002 describes test methods, defect definitions, acceptance criteria, and illustrations for assessing the solderability of electronic component leads, terminations, solid wire, stranded wire, lugs and tabs.

J-STD-003 Solderability Tests for Printed Boards

Much of the acceptability criteria of the Standard deals with the condition of solder connections. The quality of a solder connection is dependent to a great degree on the solderability of the materials being soldered. J-STD-003 describes the recommended test methods, defect definitions and illustrations for assessing the solderability of printed board surface conductors, attachment lands, and plated through holes.

J-STD-004 Requirements for Soldering Fluxes

Increased emphasis on the elimination of ozone depleting products, including many popular solvents and cleaners, has resulted in the use of low solids and no-clean fluxes to replace rosin based fluxes. Recognizing the impact of cancellation of the former military specification (Mil-F-14256) covering flux formulations, J-STD-004 was developed. This standard prescribes general requirements for the classification and testing of fluxes for high quality interconnections using tin/lead, near-eutectic alloy solder. The standard is a flux characterization, quality control, and procurement document for flux and flux containing material.

J-STD-020 Moisture/Reflow Sensitivity Classification for Nonhermetic Solid State Surface Mount Devices

The standard identifies the classification level of non-hermetic solid state Surface Mount Devices (SMDs) that are sensitive to moisture-induced stress so that they can be properly packaged, stored, and handled.

J-STD-033 Standard for Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices

Provides SMD manufacturers and users with standardized methods for handling, packing, shipping, and use of moisture/reflow sensitive SMDs.

2.3 EOS/ESD Association Documents³

ANSI EOS/ESD S3.1 EOS/ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Ionization.

ANSI/ESD S8.1 ESD Awareness Symbols

ANSI/ESD-S-20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment

This new standard covers the requirements necessary to design, establish, implement, and maintain an Electrostatic Discharge (ESD) Control Program. It applies to activities that manufacture, process, assemble, install, package, label, service, test, inspect or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to 100 volts. When handling devices susceptible to less than 100 volts, more stringent ESD Control Program Technical Requirements may be required.

2.4 Electronics Industries Alliance Documents⁴

EIA-471 Symbol and Label for Electrostatic Sensitive Devices

2.5 International Electrotechnical Commission Documents⁵

IEC/TS 61340-5-1 Protection of Electronic Devices from Electrostatic Phenomena - General Requirements

2.6 Federal Standards⁶

MIL-HDBK-263 Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices) (Metric)

3. www.esda.org

4. www.eia.org

5. www.iec.ch

6. <http://astimage.daps.dla.mil/quicksearch/>

3 HANDLING ELECTRONIC ASSEMBLIES

This section serves as an introduction to Section 3 and provides an overview of the contents of Section 3. It also:

- Defines ESD,
- Defines EOS,
- Defines ESDS components,
- Describes the types of ESD/EOS failures, and
- Refers readers to ANSI/ESD-S-20.20 for additional information.

Section 3 of the Standard provides guidance and suggestions for controlling EOS/ESD and for handling assemblies. The Standard does not define any mandatory requirements as being applicable to the limiting or control of EOS/ESD.

3.1 Electrical Overstress (EOS) Damage Prevention

This section discusses, in general terms, the ESD sensitivity level of various types of components. In addition to generic information on ESD sensitivity level, this section provides some general recommendations on voltage spike generation limits for assembly equipment and notes that periodic testing of equipment may be warranted.

3.1 Electrical Overstress (EOS) Damage Prevention

3.1 Electrical Overstress (EOS) Damage Prevention

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 must never generate spikes greater than 0.3 volt.

As required by most ESD specifications, periodic testing may be warranted to preclude damage as equipment performance may degrade with use over time. Maintenance programs are also necessary for process equipment to ensure the continued ability to not cause EOS damage.

Periodic testing of ESD protective materials and equipment depends on company policy. Customary periodic tests for various equipment includes:

- Wrist straps, heel grounding straps, static dissipative footwear
- Ground integrity static decay rate of Static dissipative flooring
- Ground integrity, surface conductivity and static decay rate of ESD dissipative work surfaces
- Ground integrity of soldering tools, solder pots, similar assembly equipment

Typical EOS/ESD programs used by industry include the following; see ANSI/ESD-S-20.20 that supersedes the reference to EIA-625 in the Standard:

- ESD Control Program Plan
- Training Plan
- Training Plan Requirement
- Compliance Verification Plan
- Grounding / Bonding Systems
- Grounding / Bonding Systems Requirements
- Personnel Grounding
- Personnel Grounding Requirement
- Protected Areas
- Protected Areas Requirement
- Packaging
- Packaging Requirements
- Marking Requirements
- Assemblies and Equipment
- Handling Procedure Requirements

3.2 Electrostatic Discharge (ESD) Damage Prevention

Table 3-1 (Table 3-1 of the standard) lists typical static charge sources. Table 3-1 should not be considered all-inclusive as almost any insulator can, under the right circumstances, generate and retain a static charge. Table 3-2 (Table 3-2 of the standard) lists typical static voltage generation and includes general information on the nature of insulating materials in generating and holding static charges. Information in Table 3-2 relates static charge generation to relative humidity. Relative humidity, while reducing the effect of triboelectric charge generation, should not be dependent on ESD control. This section also references, in the last paragraph, the possibility of induction charging of a person's body or other objects.

Relative humidity in the workplace is used to control generation of ESD charges. Static charges are generated when two insulative surfaces that are in intimate contact are separated; see MIL-HDBK-263 and ANSI/ESD-S-20.20 for more information.

3.2.1 ESD Damage Prevention - Warning Labels A number of previously used symbols have been replaced by the two shown in the Standard.

The absence of a symbol does not necessarily mean that the assembly is not ESD sensitive. **When doubt exists about the sensitivity of an assembly, it must be handled as a sensitive device until it is determined otherwise.** Typically, ESD Control/Prevention Training Programs emphasize that not all ESD sensitive components or assemblies are marked as sensitive items; see 3.1.

3.2.2 ESD Damage Prevention - Protective Materials

Most companies require that all ESD sensitive (ESDS) items be protected from static damage. However, some static sensitive items may NOT be identified as static sensitive and it is best to protect all electronic assemblies from static damage.



Table 3-1 Typical Static Charge Sources

Work surface	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 Nonconductive 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 3-2 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.

An ESDS item is subject to EOS/ESD damage any time it is not within protective packaging, even though it is wrapped in anti-static material. When assembly activities are completed on an ESDS item, the item should immediately be packaged in protective packaging material.

3.2.2 ESD Damage Prevention - Protective Materials

3.2.2 ESD Damage Prevention - Protective Materials

It is important to understand the difference between the three types of protective enclosure material: (1) static shielding (or barrier packaging), (2) antistatic, and (3) static dissipative materials.

Paragraph 6.2.4.2 of ANSI/ESD-S20.20 states in part:

“THE OBJECTIVE OF ESD PROTECTIVE PACKAGING IS TO PREVENT A DIRECT ELECTROSTATIC DISCHARGE TO THE ESDS ITEM CONTAINED WITHIN AND ALLOW FOR DISSIPATION OF CHARGE FROM THE EXTERIOR SURFACE. IN ADDITION, THE PACKAGING SHOULD MINIMIZE CHARGING OF

THE ESDS ITEM IN RESPONSE TO AN EXTERNAL ELECTROSTATIC FIELD AND TRIBOELECTRIFICATION. USERS SHOULD BE AWARE THAT SOME PACKAGING MATERIALS MAY BE HUMIDITY DEPENDENT AND MAY HAVE LIMITED SHELF LIFE. THEY MAY ALSO LOSE STATIC SHIELDING PROPERTIES BY CRUMPLING, PUNCTURING AND FOLDING.”

3.2.2 continued

Static shielding packaging will prevent an electrostatic discharge from passing through the package and into the assembly causing damage.

Packaging that is “static shielding” fully meets the definition of protective packaging and is the preferred method of packaging ESDS items.

3.2.2 continued

Antistatic (low charging) packaging materials are used to provide inexpensive cushioning and intermediate packaging for ESDS items. Antistatic materials do not generate charges when motion is applied. However, if an electrostatic discharge occurs, it could pass through the packaging and into the part or assembly, causing EOS/ESD damage to ESDS components.

Antistatic material does not fully meet the definition of protective packaging because it does not prevent static fields from creating a static charge on the items covered by, or wrapped in, antistatic material.

3.2.2 continued

Static dissipative materials have enough conductivity to allow applied charges to dissipate over the surface relieving hot spots of energy. Parts leaving an EOS/ESD protected work area must be overpacked in static shielding materials, which normally also have static dissipative and antistatic materials inside.

Not all static-protective packaging materials include static dissipative materials on internal surfaces. Check the manufacturer’s specifications for different features of each static protective material used.

3.3 EOS/ESD Safe Workstation/EPA

3.3 EOS/ESD Safe Workstation/EPA

For ESD protection, a path-to-ground must be provided to neutralize static charges that might otherwise discharge to a device or assembly. ESD safe workstations/EPAs also have static dissipative or antistatic work surfaces that are connected to a common ground. Provisions are also made for grounding the worker’s skin, preferably via a wrist strap to eliminate charges generated on the skin or clothing.

The static safe workstations shown in Figures 3-2 and 3-3 of the Standard are typical configurations that will achieve

satisfactory ESD protection for most assemblies. Of primary importance is making sure the path to ground is intact. In discussing the grounding of equipment and personnel, paragraph 6.2.1.2 of ANSI/ESD-S20.20 states: **“IN MOST CASES, THE THIRD WIRE (GREEN) AC EQUIPMENT GROUND IS THE PREFERRED CHOICE FOR GROUND. WHEN THE THIRD WIRE AC EQUIPMENT GROUND IS NOT AVAILABLE OR IMPRACTICAL TO USE, PERSONNEL SHOULD BE BONDED OR ELECTRICALLY CONNECTED TO A CONDUCTIVE ELEMENT OF THE ESDS ITEM USING A WRIST STRAP OR OTHER GROUNDING SYSTEM TO ENSURE THAT ALL ELEMENTS ARE AT THE SAME ELECTRICAL POTENTIAL.”**

3.3 continued

Provision must be made in the grounding system to protect the worker from live circuitry as the result of carelessness or equipment failure. This is commonly accomplished through resistance in line with the ground path, which also slows the charge decay time to prevent sparks or surges of energy from ESD sources. Additionally, a survey must be performed of the available voltage sources that could be encountered at the workstation to provide adequate protection from personnel electrical hazards.

The human body can tolerate substantial voltage, as evidenced by the presence of static charges of 35,000 volts or more that may be developed by walking across a carpet (Table 3-2). However, the human body can not tolerate the flow of very much current through the body tissue. The series resistance of the personal wrist strap functions to limit current through the body of the wearer, thereby protecting the wearer from possible injury. The typical effect of electric current on humans is shown in Table 3-3.

Table 3-3 Effect of Electric Current on Humans

AC 60 Hz Current Value (Milliamperes)	DC Current Value (Milliamperes)	Effects
0 - 1	0 - 4	Perception, recognition
1 - 4	4 - 15	Surprise
4 - 21	15 - 80	Reflex action (will jerk away from voltage source)
21 - 40	80 - 160	Muscular inhibition (unable to get away from voltage source)
40 - 100	160 - 300	Respirator block
Over 100	Over 300	Usually fatal.

To assure personnel safety and ESD Control Procedures are effective, it is important that personal wrist straps and/or heel grounding straps be checked periodically (daily or twice daily is preferred) for electrical continuity and proper resistance.

Table 3-4 (Table 3-3 of the Standard) provides maximum allowable resistance and discharge times for static safe operations.

Table 3-4 Maximum Allowable Resistance and Discharge Times for Static Safe Operations

Reading from Operator Through:	Maximum Tolerable Resistance	Maximum Acceptable Discharge Time
Floor mat to ground	1000 megohms	Less than 1 sec.
Table mat to ground	1000 megohms	Less than 1 sec.
Wrist strap to ground	100 megohms	Less than 0.1 sec.

3.3 continued

Note: The selection of resistance values are to be based on the available voltages at the station to ensure personnel safety as well as to provide adequate decay or discharge time for ESD potentials.

The total resistance of the static protective workstation determines the rate at which a static charge is dissipated, or drained to ground. As can be seen in Figures 3-2 and 3-3 of the Standard, the effect of having the wrist strap in a “series” or “parallel” configuration influences the total resistance and the rate of charge dissipation.

3.3 continued

Examples of Acceptable workstations are shown in Figures 3-2 and 3-3. When necessary, air ionizers may be required for more sensitive applications. The selection, location, and use procedures for ionizers must be followed to ensure their effectiveness.

An air ionizer creates positive and negative ions which, when directed toward a static charge, neutralizes the charge. Unless properly balanced, an ionizer does not create an equal number of positive and negative ions and can result in the creation of a static charge. Additional information on proper use of ionization in eliminating static charges is available in ANSI EOS/ESD S 3.1, EOS/ESD Association Standard for the Protection of Electrostatic Discharge Susceptible Items - Ionization.

3.3 continued

Note: Because of the unique conditions of each facility, particular care must be given to “third wire” ground terminations. Frequently, instead of being at workbench or earth potential, the third wire ground may have a “floating” potential of 80 to 100 volts. This 80 to 100 volt potential between an electronic assembly on a properly grounded EOS/ESD workstation/EPA and a third wire grounded electrical tool may damage EOS sensitive components or could cause injury to personnel. Most ESD specifications also require these potentials to be electrically common. The use of ground fault interrupter (GFI) electrical outlets at EOS/ESD workstations/EPAs is highly recommended.

Ground circuits in older buildings commonly have sufficient oxidization to increase the resistance to ground and result in the “ground” circuit having a possibly damaging voltage level. In addition, ground circuits may carry large transient voltage spikes that are generated when high wattage plant equipment (heating/cooling systems, vibration systems, etc.) is operating. A line voltage transient monitor/recorder can be used to detect the presence of such transients.

3.4 Handling**3.4.1 Handling - Guidelines****3.4.1 Handling - Guidelines**

Care must be taken during acceptability inspections to ensure product integrity at all times. Table 3-4 provides general guidance. Moisture sensitive components (as classified by J-STD-020 or equivalent documented procedure) must be handled in a manner consistent with J-STD-033 or an equivalent documented procedure.

3.4.1 IPC-A-610C Amendment 1

The words “must be handled” are changed to “should be handled.”

Assembly procedures should be designed to minimize non-essential handling. The guidelines of Table 3-4 are general in nature and need to be tailored and supplemented to accommodate the type of assembly process being conducted. For instance, if a “no-clean” process is in use, it is essential that all handling be performed in a manner that avoids contamination of the parts being assembled. Handling should include storage of parts and material that does not degrade solderability and does not expose moisture sensitive components to humidity.

Moisture can be absorbed by the plastic component bodies. Reflow temperatures can vaporize the moisture causing cracking and delamination (popcorning) of the components.

3.4.2 Physical Damage**3.4.3 Handling - Contamination****3.4.3 Handling - Contamination**

Contamination by handling with bare hands or fingers without some form of protection may cause 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.

Handling of parts and assemblies is a major contributing factor to contamination of assemblies. In a no-clean process the cleanliness level of all parts and components used to make up the assembly should, at the beginning of the assembly activity, be “clean enough to meet the end item cleanliness requirement.” Next, and most importantly, the parts and components must be handled and processed in a manner that does not degrade or compromise their original clean condition.

3.4.4 Handling - Electronic Assemblies**3.4.5 Handling - After Soldering****3.4.6 Handling - Gloves and Finger Cots****3.4.6 Handling - Gloves and Finger Cots**

The use of gloves or finger cots may be required under contract to prevent contamination of parts and assemblies. Gloves and finger cots must be carefully chosen to maintain EOS/ESD protection.

When using gloves, as shown in Figure 3-4 of the Standard, woven gloves become contaminated from the inside out by skin oils and perspiration and all types of hand and finger protective coverings will become contaminated on the outside and need to be replaced periodically.

Handling the PWA as shown in Figure 3-5 of the Standard is acceptable ONLY when the PWA is handled by the board edges and care is taken to avoid contact with portions of the assembly that are to be soldered or conformal coated. The illustrations also show that wrist straps are in use.

The Standard does not establish nonconformance criteria for this requirement; see 1.4.3.5.

4 MECHANICAL ASSEMBLY

4 MECHANICAL ASSEMBLY

This section covers visual criteria. Compliance to torque requirements is to be verified as specified by customer documentation. The verification procedure ensures that no damage to components or assembly occurs. Where torque requirements are not specified, follow standard industry practices.

The criteria for mechanical assembly do not include any analytical or measured value for torque or compression. If measurable requirements for specific torque or other mechanical acceptance values or criteria are needed, they should be added to the contract, assembly drawing or documented assembly process and/or inspection instructions.

4.1 Hardware

4.1 Hardware

This section illustrates several types of mounting hardware. Process documentation will specify what to use (drawings, prints, parts list, build process); deviations need to have prior customer approval.

Visual inspection is performed to verify the following conditions:

- Correct parts and hardware.
- Correct sequence of assembly.
- Correct security and tightness of parts and hardware.
- No discernable damage.
- Correct orientation of parts and hardware.

Visual confirmation of the correct parts and hardware does not assure that the correct hardware has been used. Replacement of a stainless steel nut with a nut of a different material may cause corrosion to occur.

4.2 Swaged Hardware

4.2.1 Hardware Mounting - Electrical Clearance

4.2.1 IPC-A-610C Amendment 1

The reference to 1.4.10 was corrected to 1.4.5 by Amendment 1.

4.2.1 Hardware Mounting - Electrical Clearance

Acceptable - Class 1,2,3

- Specified minimum electrical clearance. Shown in this example as the distances between 1 & 2 and 1 & 5.

The distance shown between 1 & 2 and 1 & 5 meets or exceeds the “minimum electrical clearance.”

Minimum electrical clearance (listed as Minimum Electrical Spacing in IPC-T-50) is defined as: “The minimum allowable distance between adjacent conductors, at a given

voltage and altitude, that is sufficient to prevent dielectric breakdown, corona, or both, from occurring between the conductors.” Minimum electrical clearance is a value determined by the designer and is based on several factors. See Appendix A of the Standard for a specific dimensional value for minimum electrical clearance.

4.2.1 continued

Defect - Class 1,2,3

- Hardware reduces spacing to less than specified minimum electrical clearance.

See Figure 4-2 of the Standard. The hardware that reduces the spacing to less than minimum electrical clearance need not be connected to the ground or any other circuit element for this to be a defect.

4.2.2 Hardware Mounting - Excess Solder

4.2.2 Hardware Mounting - Excess Solder

Defect - Class 1,2,3

- Excess solder (uneven) on mounting holes where mechanical assembly will be affected.

See Figure 4-3 of the Standard. Attached hardware can become loose due to gradual cold flow of solder as a result of applied pressure. In cases of extreme over pressure due to excessive tightening, the solder may eventually fracture and pieces may detach and become mobile inside the assembly.

4.2.3 Hardware Mounting - Threaded Fasteners

4.2.3 Hardware Mounting - Threaded Fasteners

A minimum of one and one half threads need to extend beyond the threaded hardware, (e.g., nut) unless otherwise specified by engineering drawing. Bolts or screws may be flush with the end of the threaded hardware only where threads could interfere with other components or wires and when locking mechanisms are used. Thread extension should not be more than 3.0 mm [0.12 in] plus one and one-half threads for bolts or screws up to 25 mm [0.984 in] long or more than 6.3 mm [0.248 in] plus one and one-half threads for bolts or screws over 25 mm [0.984 in]. This is providing that the extension does not interfere with any adjacent part and that the designed electrical clearance requirements are met.

The requirement for one and one-half threads to extend beyond the surface of the threaded hardware (e.g. nut) assures that the full diameter of the threads is in contact with the threaded hardware. Most threads are cut into the round shaft of the bolt with a tapered die. Use of a tapered die causes the threads at the end of the threaded shaft to be smaller in diameter than those on the body of the bolt. If the smaller diameter threads are in contact with the threaded hardware (nut), then the hardware is not

remain secure. Additionally, providing thread extension beyond the threaded hardware assures full tensile strength is developed.

4.2.3 continued

Defect - Class 1,2,3

- Lock washer against nonmetal/laminate.
- Flat washer missing.

Either the flat washer shown in Figure 4-5 or the functionally similar internal tooth or external tooth washers, damage the laminate surface and eventually abrade a hole in the laminate surface. With abrasion of a hole, the lock washer loses the ability to secure the nut (or other threaded hardware) and loosen.

4.2.3.1 Hardware Mounting - Threaded Fasteners - Minimum Torque for Electrical Connections

4.2.3.1 Hardware Mounting - Threaded Fasteners - Minimum Torque for Electrical Connections

When electrical connections are made using threaded fasteners they must be tight to ensure the reliability of the connection. When split-ring type lock washers are used, the threaded fastener must be tight enough to compress the lock washer. When required, fasteners are tightened to the specified minimum torque value.

If a minimum torque value is appropriate then it must be specified or identified by contract or assembly drawing. The acceptance requirements of the Standard do not include any analytical tests or measurement of parameters such as torque.

4.2.3.2 Hardware Mounting - Threaded Fasteners - Wires

4.2.3.3 Hardware Mounting - Threaded Fasteners - High Voltage Applications

4.2.4 Component Installation

4.2.4.1 Hardware Mounting - Component Installation - High Power

4.2.4.1 Hardware Mounting - Component Installation - High Power

Acceptable - Class 1,2,3

- Hardware in proper sequence.
- Leads on components attached by fastening devices are not clinched. (Not shown)

Note: Where a thermal conductor is specified, it must be placed between mating surfaces of the power device and the heat sink. Thermal conductors may consist of a thermally conductive washer or of an insulating washer with a thermally conductive compound.

See Figure 4-16 of the Standard. The installation of a flat washer will provide a solid surface against which the split ring lock washer shown (or internal or external tooth lock washers) can be secured without damaging the laminate surface.

Leads on components that are attached by fastening devices are usually large in diameter (1.25 mm or 0.050 inch) and are frequently made of an iron-based material such as Kovar® or Alloy 42. Larger leads, usually associated with high current, are sometimes made of Kovar® or Alloy 42 so that a hermetic seal can be formed where the lead enters the component body. At the junction of the lead and component body a small glass frit encircles the lead. Bending or forming of the lead damages the glass frit and results in loss of hermeticity, resulting in reduced component reliability. Large diameter leads, or leads made of iron based material should not be clinched, bent or formed.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

4.2.4.1 continued

Acceptable - Class 1,2,3 See Figure 4-18 on page 4-13 of the Standard.

- Insulating washer provides electrical isolation when required.
- Hardware in proper sequence.

In cases where a terminal lug (as shown in Figures 4-18 and 4-19) is not required, a flat washer should be installed to prevent the toothed washer from damaging the insulating material.

4.2.4.2 Hardware Mounting - Hole Obstruction of Solder Fill.

4.2.4.2 Hardware Mounting - Hole Obstruction of Solder Fill

Acceptable - Class 1,2,3

- Parts and components are mounted such that they do not prevent fill of plated-through holes that are required to be soldered.

See Figure 4-20 of the Standard. Although not depicted because the drawing is not to scale, there is sufficient vertical clearance at the top surface of the PWA for solder to crest over the knee of the plated through hole without shorting the component lead to the component case/package.

4.2.4.2 continued

Process Indicator - Class 2

Defect - Class 3

- Parts and components prevent fill of plated-through holes that are required to be soldered.

See Figure 4-21 of the Standard. Hole obstruction usually occurs when components are flush mounted to the topside of a circuit board. The component body rests on the top of the board while the leads extend through the PTH; see Figure 4-21. Topside hole obstruction can result in solder defects. The component “caps off” the hole, which traps air and flux during the soldering process, resulting in a partially filled hole.

4.3 Swaged Hardware

4.3 Swaged Hardware

Inspection of swaged hardware is generally visual, but microsection methods are recommended for qualification testing.

Automated and semi-automated equipment used for swaging hardware can be adjusted quite precisely. Destructive physical analysis (microsection) is typically used when setting up swaging equipment to assure that the PCB laminate is not damaged.

4.3.1 Swaged Hardware - Flared Flange

4.3.1 Swaged Hardware - Flared Flange

The shank extending beyond the land surface is swaged to create an inverted cone, uniform in spread, and concentric to the hole.

The flange is not split, cracked or otherwise discontinuous to the extent that flux, oils, inks, or other liquid substances utilized for processing the printed wiring assemblies can be entrapped within the mounting hole. After swaging, the area is free of circumferential splits or cracks, but may have a maximum of three radial splits or cracks provided that the splits or cracks are separated by at least 90° and do not extend into the barrel of the terminal.

Acceptable - Class 1

- Split in flared flange in barrel Acceptable if soldered after swaging.

Defect - Class 2, 3

- Flared flange periphery uneven or jagged.
- Split enters into barrel.
- Any circumferential splits/cracks.

Flared flange angle is the distortion of the straight terminal shanks outward used to hold/retain the terminal to the PCB prior to soldering. The mechanical fit of the terminal after flaring should be tight enough so that the terminal does not tilt, but loose enough to be hand-rotated. The flare is for mechanical retention prior to and during the soldering operation. If the flare is too tight, solder does not flow upwards into the mounting hole and may result in laminate damage because of thermal expansion during the soldering process. If the flare is too loose, the terminal could tilt during soldering. The terminal swaging tool should be

adjusted to produce a flare within the specification requirements. Inspecting the appropriate flared angle is difficult and the tooling must be controlled to ensure that consistent forming of the flare is accomplished.

Circumferential cracks or splits are those that run cross-sectional to the shank vertical axis. When discontinuities are present and processing fluids are allowed to enter the mounting hole, the subsequent soldering process may result in entrapment, blow holes, or other defects. Circumferential cracks in shanks can propagate into a complete separation.

Flange discontinuities are similar to shank discontinuities, except that they occur in the swaged or rolled area of the terminal. These types of discontinuities are not as serious as shank discontinuities; therefore, some relief is allowed. These types of discontinuities can contribute to the same resultant defects as do shank discontinuities. The process to roll or flare the flange during the installation of the terminal must be controlled, such that radial cracks and splits do not occur in quantities or the physical relationship beyond the allowed requirements.

The introduction (listed at the beginning of the section) states that: “After swaging, the area is free of circumferential splits or cracks, but may have a maximum of three radial splits or cracks provided that the splits or cracks are separated by at least 90° and do not extend into the barrel of the terminal.”

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

4.3.1.1 Swaged Hardware - Flared Flange - Controlled Split

4.3.2 Swaged Hardware - Flat Flange - Fused-in-Place

“Fused-in-Place” is the same as solder-in-place. The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

4.3.3 Terminals

4.4 Component Mounting See Figure 4-36 of the Standard. If spacing is reduced to below the minimum acceptable value because the insulator (Item 3 of Figure 4-35) is missing from the assembly, then two defects exist. One is a result of a violation of minimum electrical clearance and the second is a result of “hardware missing or improperly installed”; see Figure 4-7 on page 4-7 of the Standard.

4.4.1 Component Mounting - Mounting Clips See Figure 4-37 on page 4-24 of the Standard. Mounting of non-insulated components over active circuitry can cause a short. If there is no circuitry or if the circuitry is insulated,

the component can be mounted flush, which provides for the most secure mounting. Visual examination of the assembly provides the answer as to whether the non-insulated component is mounted over exposed circuitry. When this is the case, the component must be formed to have the desired spacing between the component body and the board circuitry.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

4.4.2 Component Mounting - Adhesive Bonding - Non-Elevated Components See Figure 4-38 on page 4-25 of the Standard. The Standard depicts adhesive bonding material applied to only one side of a horizontally mounted component. Although not specifically noted in this section, the acceptability criteria are intended to be applicable to both sides of a horizontally mounted nonelevated axial leaded component. Failure to meet the acceptability criteria on either side of the component is a defect.

IPC-SM-817 provides information on many of the elements necessary in the choice, application, and evaluation of component attachment (nonelectrical) adhesives.

4.4.3 Component Mounting - Adhesive Bonding - Elevated Components

4.4.3 Component Mounting - Adhesive Bonding - Elevated Components

Acceptable - Class 1,2,3

- A. Bonding requirements should be specified in engineering documents, but as a minimum, components weighing 7g or more per lead are bonded to mounting surface in at least four places evenly spaced around component when no mechanical support is used.
- B. At least 20% of the total periphery of the component is bonded.
- C. Bonding material firmly adheres to both the bottom and sides of the component and to the printed wiring board.

See Figure 4-43 of the Standard. Acceptability criterion B does not mean that more bonding is better. Under ideal conditions, approximately 30% of the periphery of the component would be bonded to the mounting surface. If 50% or more of the periphery is bonded the ability to inspect solder connections is minimized and the probability of trapping process residues under the component is increased. A component should not be completely surrounded with bonding material, since doing so eliminates the ability of a cleaning system to extract process residuals and also render visual inspection of solder connection integrity impossible.

4.4.4 Component Mounting - Mounting Clips

4.4.5 Component Mounting - Cable Ties, Tie Wraps, Spot Ties

4.4.5 Component Mounting - Cable Ties, Tie Wraps, Spot Ties

Acceptable - Class 1,2,3

- Example of clove-hitch tie method; square knot used to preclude the tie from loosening.
- Other knots used e.g., surgeons knot etc., to secure the clove hitch from loosening must be a type that will prevent loosening in the intended service environment.

Defect - Class 1,2,3

- Cable tied with an improper hitch or knot. This tie may eventually loosen.

4.4.5 IPC-A-610C Amendment 1

IPC-A-610C Amendment 1 clarifies this requirement by changing the words in Defect Class 1,2,3 by Figure 4-52 from “bow knot” to “improper hitch or knot.”

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

4.4.6 Component Mounting - Lacing Some users may request or require that the running knots of lacing be a lock knot instead of the lacing knots depicted in Figure 4-53 of the Standard. The running lock knot example shown here is from IPC/WHMA-A-620.

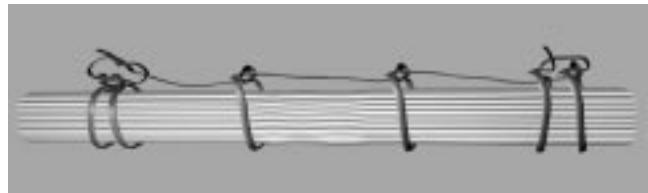


Figure 4-1 Running Lock Knot

4.4.7 Component Mounting - Wire Dress for Terminations to Connectors Without Strain/Stress Relief

4.4.7 IPC-A-610C Amendment 1

IPC-A-610C Amendment 1 changes the words in the Note next to Figure 4-55 from “The number of contacts with no fanout slack...” to “The number of wires with no slack...”

4.5 Connectors, Handles, Extractors

4.6 Heatsink See Figure 4-59 of the Standard. The heatsink-securing hardware needs to be tightened prior to soldering component leads. If component leads are soldered prior to tightening of hardware there may be stress in the solder connection.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

4.6.1 Heatsink - Insulators and Thermal Compounds

See Figure 4-61 of the Standard. Components, such as the one depicted by Figures 4-61, 4-62, and 4-63 of the Standard, are usually high current devices that have large leads (pins) that are 0.125 mm [0.050 in] in diameter. Such large leads can become failure mechanisms if they are clinched or bent because they are sometimes made of Kovar® or Alloy42 so that a hermetic seal can be formed where the lead enters the component body. At the junction of the lead and component body a small glass frit encircles the lead. Bending or forming of the lead damages the glass frit and results in loss of hermeticity, resulting in reduced component reliability. Most components of this type are not soldered to the plated through hole because the PTH has been substantially enlarged to allow ample clearance around the lead. Usually, interconnect wires are soldered directly to the lead (pin), although other attachment methods can also be used.

The assembly drawing should require insulation for metal-cased components between the metal component body and adjacent conductive surfaces. Metal-cased component bodies are conductive and short electrical potentials between conductors if allowed to contact these surfaces. Permanent solder mask generally does not constitute an acceptable insulation for this purpose. The dielectric properties of the solder mask should be determined for acceptable values if it is to be used beyond intended material requirements (i.e., insulation).

4.6.2 Heatsink - Contact When the component is not mounted flush, heat transfer may be impacted.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

4.7 Terminals - Edge Clip

4.8 Connector Pins

4.8.1 Connector Pins - Edge Connector Pins

4.8.2 Connector Pins - Press-Fit Pins See Figure 4-75 of the Standard. The Defect for a Class 3 product is independent of whether the land is functional or nonfunctional. A Defect condition exists if any land on a Class 3 product is lifted by any amount.

5 COMPONENT INSTALLATION LOCATION/ ORIENTATION COMPONENT CLEANLINESS

In addition to the component mounting criteria defined in Section 5, components should be handled and mounted in a manner that does not contribute any contaminants to the assembly. Prior to any soldering operation, the components to be soldered should be clean and free of any contaminants that would interfere with the soldering process. Clean components should be handled in a manner that prevents transfer of contaminants onto the solderable surfaces of the component leads or terminations. Contaminated components should be cleaned with a process that adequately removes the contamination but does not damage the component.

5.1 Orientation

5.1.1 Orientation - Horizontal

5.1.2 Orientation - Vertical

5.2 Mounting

5.2.1 Mounting - Horizontal - Axial Leaded - Supported Holes

5.2.1 Mounting - Horizontal - Axial Leaded - Supported Holes

Target - Class 1,2,3

- The entire body length of the component is in contact with the board surface.
- Components required to be mounted off the board are at least 1.5 mm [0.059 in] from the board surface; e.g., high heat dissipating.

See Figure 5-7 of the Standard. Spacing of axial-leaded components is a critical factor because of the strength attributed to the solder connections. Of particular concern is the height, or Z-axis, of the mounted component. Operational vibrations of the assembly may cause fractured solder connections when the components are mounted excessively high off the PCB.

The component body should be against the PCB surface, or as close to the board as possible, to minimize damage to solder connections during vibration or shock.

High wattage components are frequently mounted above the PCB surface to allow more exposed surface area for convection cooling. Note that the former version of the Standard (Revision B) required components that dissipated 1-watt or more to be mounted 1.5 mm or more from the surface of the PWA. Revision C of the Standard recognizes that mounting components above the PWA surface is a

design issue and therefore does not specify a wattage rating. The Standard does specify a minimum height (1.5 mm) for use where a component is required to be elevated and no specific dimension is provided by drawing or assembly instructions.

5.2.2 Mounting - Horizontal - Axial Leaded - Unsupported Holes See Figure 5-7 of the Standard. The component body should be against the PCB surface, or as close to the board as possible, to minimize damage to solder connections during vibration or shock. High wattage components are frequently mounted above the PCB surface to allow more exposed surface area for convection cooling. Components mounted above the PCB surface on boards with unsupported holes must be equipped with lead forms on the primary side of the board. This assures that any downward pressure on the component does not fracture or damage the solder connection or circuitry on the secondary side of the PWA.

The definition of an unsupported hole is: "A hole in a printed board that does not contain plating or other type of conductive reinforcement." Solder connections on single-sided boards (unsupported holes) are not as mechanically robust as a solder connection using a plated through hole. When soldering a lead or wire into an unsupported hole it is necessary to provide lead form (as shown in Figure 5-12 of the Standard) to prevent any downward pressure on the component from being transmitted to the solder connection and circuitry.

Components mounted above the PCB surface on boards with unsupported holes must be equipped with lead forms or spacers on the primary side of the board. This assures that any downward pressure on the component does not fracture or damage the solder connection on the secondary side of the PWA.

5.2.3 Mounting - Horizontal - Radial Leaded

5.2.3 Mounting - Horizontal - Radial Leaded

Target - Class 1,2,3

- The component body is in flat contact with the board's surface.
- Bonding material is present, if required. See 4.4.

5.2.3 IPC-A-610C Amendment 1

IPC-A-610C Amendment 1 corrects a grammar error by changing the words in the Note next to Figure 5-16 to "The body should be bonded or otherwise secured..."

See Figure 5-15 of the Standard. Radial leaded components are mounted horizontally to better withstand vibration and mechanical shock and also to avoid violating the maximum

z-axis design envelope of the circuit card assembly. The side or surface of the body, or at least one point of any irregularly configured component (such as certain pocket-book capacitors), should be in full contact with the printed board. The body should also be bonded or otherwise retained to the board to prevent damage when vibration and shock forces are experienced during normal use.

5.2.4 Mounting - Vertical - Axial Leaded - Supported Holes

5.2.4 Mounting - Vertical - Axial Leaded - Supported Holes

Target - Class 1,2,3

- The height of the component body above the land, (H) is 0.4 mm [0.016 in] to 1.5 mm [0.059 in].
- The component body is perpendicular to the board.
- The overall height does not exceed the height specified.

See Figure 5-18 of the Standard. When vertically mounting an axial leaded component above the board it is desirable that Dimension H complies with Table 5-1 unless otherwise specified in the drawing or through use of a required standoff. Primary reasons for Dimension H include:

- To allow for expansion/contraction during temperature change without damaging the seal at the interface of the lead and component body,
- To assure that the portion of the lead in the plated through hole is solderable (some component manufacturers do not assure solderability for the first 0.050 inch of lead from the component body),
- To assure that the cleaning system in use has sufficient clearance to extract process residuals from beneath the component, and
- To assure that sufficient vertical clearance exists for inspection to verify the integrity of the topside solder fillet including circumferential wetting of solder to both lead and barrel.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

5.2.4 continued

Acceptable - Class 1

Process Indicator - Class 2,3

- The component mounting height (H) is greater than the maximum given in Table 5-1.

Defect - Class 1,2,3

- Components violate minimum electrical clearance.

See Figure 5-20 of the Standard. The manufacturer or user may need to reclassify the condition described as a Process Indicator - Class 2, 3 to a defect. If the product is subjected

to high levels of random or sine vibration or mechanical shock, components that are elevated above the PCB surface, without additional mechanical support, reduce the reliability of the product.

The condition described as defect - Class 1, 2, and 3 should result in a rework action that includes reflow of the solder connections while correcting the position of the component. Simply using a soldering aid or thumbnail to bend the component leads and affect an increase in the clearance to an adjacent component should NOT be considered an acceptable corrective action.

5.2.4 continued

Acceptable - Class 1

Process Indicator - Class 2,3

- The component height (H) is less than the minimum given in Table 5-1.

Acceptable - Class 1

Process Indicator - Class 2

Defect - Class 3

- The inside bend radius does not meet requirements. See Table 5-3.

See Figure 5-21 of the Standard. The condition described as Process Indicator - Class 2, 3 where the component height does not equal the minimum given in Table 5-1 may need to be reclassified by the manufacturer or the user to become a defect. If the product is subjected to thermal cycling or if a high level of cleanliness is required, mounting the component with less than the minimum value of dimension H reduces reliability of the product in a thermally dynamic environment (by eliminating stress relief).

5.2.5 Mounting - Vertical - Axial Leaded - Unsupported Holes

5.2.5 Mounting - Vertical - Axial Leaded - Unsupported Holes

Defect - Class 1,2,3

- Components mounted in unsupported holes are mounted without lead form at the board surface.

See Figure 5-23 of the Standard. Although not specifically required by the Standard, sometimes the acceptability criteria for vertical mounting of axial-leaded components in supported holes could also be applied to mounting in unsupported holes. While violation of minimum electrical clearance is clearly a defect condition, any violation of dimension H of Table 5-1 might reduce the reliability of some products. (See 5.2.4 for limitation of cleaning ability, elimination of ability to inspect top-side solder fillet, elimination of stress relief, blocking of PTH.) Any defect definitions in addition to those of the Standard are within the authority of the manufacturer or the user, but must be agreed upon and thoroughly documented.

5.2.6 Mounting - Vertical - Radial Leaded

5.2.6 Mounting - Vertical - Radial Leaded

Acceptable - Class 1,2,3

- Component tilt does not violate minimum electrical clearance.

Process Indicator - Class 2,3

- Space between component base and board surface is less than 0.3 mm [0.012 in] or more than 2 mm [0.079 in].

Defect - Class 1,2,3

- Violates minimum electrical clearance.

Note: Some components cannot be tilted due to mating requirements with enclosures or panels, for example toggle switches, potentiometers, LCDs, and LEDs.

See Figure 5-25 of the Standard. The condition described as Process Indicator - Class 2, 3 where the component height does not equal the minimum of 0.3 mm [0.012 in] may need to be reclassified by the manufacturer or the user to become a defect. If the product is required to have a high level of cleanliness, then mounting the component with less than the minimum height may reduce reliability of the product by making it more difficult for the cleaning system to extract process residuals.

The component edge, side or perimeter being in contact with the board surface while the opposite edge, side or perimeter is elevated above the board surface may impact the reliability of the product if thermal cycling is encountered. The thermal cycling creates vertical stress at the junction of the component lead and body if one part of the component body was touching the board. Such vertical pressure could be sufficient to fracture the lead/body interface resulting in an open circuit or could fracture the lead/body seal (if present) resulting in loss of hermetic seal and hastening component failure.

5.2.6.1 Mounting - Vertical - Radial Leaded -Component Mounting Spacers

5.2.6.1 Mounting - Vertical - Radial Leaded - Component Mounting Spacers

Note: Spacers used for mechanical support or to compensate for component weight must be in full contact with both component and board surface.

Spacers are normally made of a resilient material to allow compensation for changes in component and board dimensions during temperature changes. This can happen through design of resilient materials or by using resilient material. As a coil spring is resilient by design (not by material) and certain plastic materials are resilient by virtue of characteristics of the material. Spacers are used to:

- Stabilize or support heavy components,
- Provide electrical isolation of a component body from the circuit traces on the board,

- Provide sufficient vertical clearance beneath a component to allow the cleaning system to extract process residuals,
- Assure that enough vertical clearance exists to allow visual inspection of solder connections, and
- Provide stress relief for the leads of components that will be subjected to significant thermal cycling.

Mechanical standoff materials/spacers, whether permanent or temporary, can entrap contaminants through contact of the board surface. Whatever standoffs are used, they should not be degraded by the soldering processes (e.g., soften or melt at reflow temperatures). In addition, the configuration of the spacer (if permanent) should not obscure the solder joint and prevent inspection or prevent adequate access of cleaning solutions if used. Temporary spacers are made of materials designed to be dissolved in a subsequent cleaning operation. Some temporary materials are water-soluble for aqueous cleaning processes and others are solvent-soluble for solvent or semi-aqueous cleaning processes. The rates of removal vary from material to material and may not be totally removed during fast or inadequate cleaning cycles. Complete removal of residues may require more than visual verification. Many of the residue detection methods outlined in IPC-TM-650 that describe extraction based testing, may be required by some users/customers.

In addition to the mechanical spacers discussed above, spacers can also serve an electrical function when used to control the distance that a frequency sensitive or frequency determining device is mounted above the PCB surface. Control drawings of assembly instructions usually include specific mounting criteria for spacers that affect electrical performance.

5.2.6.2 Mounting - Vertical - Radial Leaded - Component Meniscus

5.2.6.2 Mounting - Vertical - Radial Leaded - Component Meniscus

Acceptable - Class 1,2

- Components with a coating meniscus can be mounted with the meniscus into the holes provided they meet the requirements of 6.3.4.3.

Process Indicator - Class 3

- Coating meniscus is into the plated-through hole (must meet the requirements of 6.3.4.3).

5.2.6.2 IPC-A-610C Amendment 1

IPC-A-610C Amendment 1 provides additional criteria by adding the following next to Figure 5-32:

Defect - Class 1,2,3

- Connection does not meet the requirements of 6.3.4.3 when soldered.

See Figure 5-32 of the Standard. Some radial-mounted components have a meniscus at the lead-to-body seal.

This meniscus is formed during the molding of the component encapsulate material when the component is manufactured. This meniscus should not be trimmed. Also, the component should be mounted so that the meniscus material does not interfere with the forming of the topside solder fillet during the soldering process. Trimming the meniscus from the component may violate the lead-to-body seal of the component allowing processing materials to enter the component cavity and cause corrosion. Mounting the component with the meniscus in the through hole interferes with the natural formation of the solder fillet. The component should be mounted with a space between the meniscus and the surface of the PCB.

Temporary spacers may be positioned under the component to space the body above the board during the soldering process and can be removed after soldering is complete. Permanent spacers may be used when allowed by the drawing.

5.2.7 Wire/Lead Termination - Printed Board

5.2.7.1 Mounting - Wire/Lead Termination - Printed Board - Protrusion - Straight and Partially Clinched Leads

5.2.7.1 Mounting - Wire/Lead Termination - Printed Board - Protrusion - Straight and Partially Clinched Leads

Process Indicator - Class 2 (Supported Hole)

Defect - Class 3 (Supported Hole)

- Lead protrusion does not meet the requirements of Table 5-2.

Defect - Class 1,2,3 (Supported Hole)

- Lead protrusion violates minimum electrical clearance.

Process Indicator - Class 2 (Unsupported Hole)

Defect - Class 3 (Unsupported Hole)

- Lead protrusion is inadequate to permit lead clinching a minimum of 45°.

Defect - Class 1,2,3 (Unsupported Hole)

- Lead protrusion is less than 0.5 mm [0.020 in].
- Lead protrusion violates minimum electrical clearance.

See Figure 5-34 of the Standard. Three typical through hole mounting methods are:

- Straight-through (stud) mounting, in which the component lead is inserted through the hole and is not clinched,
- Partially-clinched mounting, in which the lead is inserted through the hole and is then bent over slightly for retention on the board, and
- Clinched (full clinch), where the lead is inserted through the hole and is then bent fully over to the board/circuitry surface for retention to the board.

Figure 5-1 is from IPC-HDBK-001 with Amendment 1.

In cases where PWA design uses components with predetermined lead lengths, e.g. DIPs, sockets, connectors, etc.,

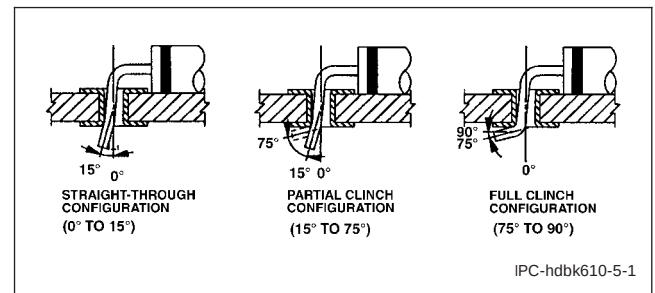


Figure 5-1 Lead Clinching

the leads may not be long enough to provide minimally acceptable lead extension. In such cases, design takes precedence over the criteria defined by the Standard. When the design results in minimal, additional inspection may be applied to the Primary Side of the PWA to confirm that the lead exhibits adequate wetting and is properly inserted into the hole.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

5.2.7.2 Mounting - Wire/Lead Termination - Printed Board - Clinched

5.2.7.2 Mounting - Wire/Lead Termination - Printed Board - Clinched

Component leads in through-hole connections may be terminated using a straight through, a partially clinched, or clinched configuration. The clinch should be sufficient to provide mechanical restraint during the soldering process. The orientation of the clinch relative to any conductor is optional. DIP leads should be bent outward from the longitudinal axis of the body. Tempered leads are not terminated with a full-clinched configuration.

As a minimum, the lead is discernable in the completed solder connection. The lead meets the requirements of Table 5-2 when measured vertically from the land surface and does not violate minimum electrical clearance requirements. Lead terminations in unsupported holes are clinched a minimum of 45° and the lead protrusion for unsupported holes is 0.5 mm [0.020 in] minimum and does not violate minimum electrical clearance requirements.

This section applies to terminations with a clinching requirement. Other requirements may be specified on relevant specifications or drawings. Partially clinched leads for part retention are considered as unclinched leads and need to meet protrusion requirements.

Bending the leads of DIP components inward, toward the centerline of the body, is discouraged because the force transmitted during lead bending and during field service can lift the lid off of the DIP device.

The term “tempered lead” is used to describe leads made of Kovar® or Alloy 42, both of which are iron-bearing materials. As an iron-bearing material, the leads are stiff and difficult to bend. Bending a tempered lead frequently

results in cracking and fracture of the lead. Thus, this practice is discouraged.

5.2.7.2 continued

Target - Class 1,2,3

- Lead end is parallel to the board and direction of the clinch is along the connecting conductor.

See Figure 5-35 of the Standard. The target condition should be the goal when clinching leads by hand. When using automatic clinching or automatic cut and clinch equipment, the direction of the lead clinch cannot be controlled so that the clinch lies along a circuit trace. However, in no case should the direction of clinch result in a condition that can cause a short circuit or otherwise result in a violation of minimum electrical clearance.

5.2.8 Mounting - Dual-in-Line Pack (DIP)/Single-in-Line Pack (SIP) Pins and Sockets See Figure 5-42 of the Standard.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.

5.2.9 Mounting - Connectors See Figure 5-44 of the Standard. Assure that connectors are firmly seated to the board surface, including final tightening of any attaching hardware, prior to soldering. Tightening attaching hardware after soldering places stress on both the solder connections and the leads or pins of the connector.

5.2.10 Mounting - Leads Crossing Conductors

5.2.10 Mounting - Leads Crossing Conductors

Acceptable - Class 1

- Component lead crossing an electrically noncommon conductor that does not violate electrical spacing.

Defect - Class 2,3

- A. Splitting and/or unraveling of sleeving.
- B. A component lead crossing an electrically noncommon conductor with a clearance of less than 0.5 mm [0.020 in] with no separating insulator (lead sleeving or surface coating).

Defect - Class 1,2,3

- Component leads and wires specified to have sleeving are not sleeved.
- Damaged/insufficient sleeving no longer provides protection from shorting.

See Figure 5-48 of the Standard. The presence of solder resist (mask) on the board surface may not satisfy the requirement for a “separating insulator” referenced in paragraph B of Defect - Class 2, 3; see page 9-7 of the Standard.

Mounting of noninsulated components over active circuitry can potentially short the circuit causing electrical failure of

the assembly. The devices should be spaced to avoid this condition. If there is no circuitry or if the circuitry is insulated, the component can be mounted flush, which provides for the most secure mounting. Visual examination of the assembly provides the answer as to whether the noninsulated component is mounted over exposed circuitry. When this is the case, the component must be formed to have the desired spacing between the component body and the board circuitry. Equipment with form/cut dies is available to accomplish this task. Hand forming may be performed using fixtures to ensure proper fit prior to soldering.

One of the performance characteristics of solder resist coatings is a known value of dielectric constant or electrical resistance, which is usually quite high. Some customers consider solder mask suitable/acceptable as an insulator between components and the PCB surface or conductors on the surface. The performance characteristics of solder mask do NOT include an assessment of dielectric constant and therefore solder resist MAY NOT be an acceptable insulator in all cases. Dielectric constant values for solder resist apply to the solder resist before assembly processing and the dielectric characteristics of the resist may be significantly changed by exposure to the assembly process.

5.3 Lead Forming

5.3.1 Lead Forming - Bends By forming the lead at least one lead diameter but not less than 0.8 mm [0.031 in] away from the component body, the chance of damaging the lead-to-body interface is lessened. This includes the distance away from the welded bead on some component (tantalum capacitors) types. Most automatic lead forming equipment is capable of performing this lead forming operation within these requirement allowances. When hand forming, the assembler should follow a procedure that isolates the stress from the component end seal.

The lead forming process may be manual or part of an automated forming and insertion operation. The mechanism for bending the leads should not impart stress to the component lead-to-body seal or the component’s internal electrical element connection. The component leads are mechanically captured prior to the forming action, and the lead-to-body seal is isolated from the force used to bend the lead over. The critical elements of lead forming are support at the lead exit from the component body, the lead forming action, and lead end trimming. To control the lead forming process, recognize when the forming action causes damage to the component. Each component should have an associated specification to which the part is procured. The specification should also have criteria covering acceptable damage limits. Any cracks or breaks in glass lead-to-body seals should be rejected; see 5.4.3 of the Standard.

The Standard does not establish nonconformance criteria for all the requirements listed; see 1.4.3.5.