



ASSOCIATION CONNECTING  
ELECTRONICS INDUSTRIES®

IPC-A-610D

# Acceptability of Electronic Assemblies

Developed by the IPC Task Group (7-31b) of the Product Assurance Subcommittee (7-30) of IPC



**Supersedes:**

IPC-A-610C - January 2000  
IPC-A-610B - December 1994  
IPC-A-610A - March 1990  
IPC-A-610 - August 1983

Incorporates modifications  
to noted errata

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

Contact:

IPC  
3000 Lakeside Drive, Suite 309S  
Bannockburn, Illinois  
60015-1219  
Tel 847 615.7100  
Fax 847 615.7105

# Table of Contents

<p><b>1 Foreword</b> ..... 1-1</p> <p><b>1.1 Scope</b> ..... 1-2</p> <p><b>1.2 Purpose</b> ..... 1-3</p> <p><b>1.3 Specialized Designs</b> ..... 1-3</p> <p><b>1.4 Terms &amp; Definitions</b> ..... 1-3</p> <p>1.4.1 Classification ..... 1-3</p> <p>1.4.2 Acceptance Criteria ..... 1-3</p> <p>1.4.2.1 Target ..... 1-4</p> <p>1.4.2.2 Acceptance Condition ..... 1-4</p> <p>1.4.2.3 Defect Condition ..... 1-4</p> <p>1.4.2.4 Process Indicator Condition ..... 1-4</p> <p>1.4.2.5 Combined Conditions ..... 1-4</p> <p>1.4.2.6 Conditions Not Specified ..... 1-4</p> <p>1.4.3 Board Orientation ..... 1-4</p> <p>1.4.3.1 *Primary Side ..... 1-4</p> <p>1.4.3.2 *Secondary Side ..... 1-5</p> <p>1.4.3.3 Solder Source Side ..... 1-5</p> <p>1.4.3.4 Solder Destination Side ..... 1-5</p> <p>1.4.4 *Cold Solder Connection..... 1-5</p> <p>1.4.5 Electrical Clearance ..... 1-5</p> <p>1.4.6 High Voltage ..... 1-5</p> <p>1.4.7 Intrusive Solder ..... 1-5</p> <p>1.4.8 *Leaching ..... 1-5</p> <p>1.4.9 Meniscus (Component) ..... 1-5</p> <p>1.4.10 Pin-in-Paste ..... 1-5</p> <p>1.4.11 Wire Diameter ..... 1-5</p> <p><b>1.5 Examples and Illustrations</b> ..... 1-5</p> <p><b>1.6 Inspection Methodology</b> ..... 1-5</p> <p><b>1.7 Verification of Dimensions</b> ..... 1-6</p> <p><b>1.8 Magnification Aids and Lighting</b> ..... 1-6</p> <p><b>2 Applicable Documents</b> ..... 2-1</p> <p><b>2.1 IPC Documents</b> ..... 2-1</p> <p><b>2.2 Joint Industry Documents</b> ..... 2-1</p> <p><b>2.3 EOS/ESD Association Documents</b> ..... 2-2</p> <p><b>2.4 Electronics Industries Alliance Documents</b> ..... 2-2</p> <p><b>2.5 International Electrotechnical Commission Documents</b> ..... 2-2</p>	<p><b>3 Handling Electronic Assemblies</b> ..... 3-1</p> <p><b>3.1 EOS/ESD Prevention</b> ..... 3-2</p> <p>3.1.1 Electrical Overstress (EOS) ..... 3-3</p> <p>3.1.2 Electrostatic Discharge (ESD) ..... 3-4</p> <p>3.1.3 Warning Labels ..... 3-5</p> <p>3.1.4 Protective Materials ..... 3-6</p> <p><b>3.2 EOS/ESD Safe Workstation/EPA</b> ..... 3-7</p> <p><b>3.3 Handling Considerations</b> ..... 3-9</p> <p>3.3.1 Guidelines ..... 3-9</p> <p>3.3.2 Physical Damage ..... 3-10</p> <p>3.3.3 Contamination ..... 3-10</p> <p>3.3.4 Electronic Assemblies ..... 3-10</p> <p>3.3.5 After Soldering ..... 3-11</p> <p>3.3.6 Gloves and Finger Cots ..... 3-12</p> <p><b>4 Hardware</b> ..... 4-1</p> <p><b>4.1 Hardware Installation</b> ..... 4-2</p> <p>4.1.1 Electrical Clearance ..... 4-2</p> <p>4.1.2 Interference ..... 4-3</p> <p>4.1.3 Threaded Fasteners ..... 4-3</p> <p>4.1.3.1 Torque ..... 4-6</p> <p>4.1.3.2 Wires ..... 4-7</p> <p><b>4.2 Connectors, Handles, Extractors, Latches</b> ..... 4-9</p> <p><b>4.3 Connector Pins</b> ..... 4-10</p> <p>4.3.1 Edge Connector Pins ..... 4-10</p> <p>4.3.2 Press Fit Pins ..... 4-12</p> <p>4.3.2.1 Soldering ..... 4-16</p> <p>4.3.3 Backplanes ..... 4-18</p> <p><b>4.4 Wire Bundle Securing</b> ..... 4-19</p> <p>4.4.1 General ..... 4-19</p> <p>4.4.2 Lacing ..... 4-22</p> <p>4.4.2.1 Damage ..... 4-23</p> <p><b>4.5 Routing</b> ..... 4-24</p> <p>4.5.1 Wire Crossover ..... 4-24</p> <p>4.5.2 Bend Radius ..... 4-25</p> <p>4.5.3 Coaxial Cable ..... 4-26</p> <p>4.5.4 Unused Wire Termination ..... 4-27</p> <p>4.5.5 Ties over Splices and Ferrules ..... 4-28</p>
--	---

## Table of Contents (cont.)

<p><b>5 Soldering</b> ..... 5-1</p> <p><b>5.1 Soldering Acceptability Requirements</b> ..... 5-3</p> <p><b>5.2 Soldering Anomalies</b> ..... 5-8</p> <p>5.2.1 Exposed Basis Metal ..... 5-8</p> <p>5.2.2 Pin Holes/Blow Holes ..... 5-10</p> <p>5.2.3 Reflow of Solder Paste ..... 5-11</p> <p>5.2.4 Nonwetting ..... 5-12</p> <p>5.2.5 Dewetting ..... 5-13</p> <p>5.2.6 Excess Solder ..... 5-14</p> <p>5.2.6.1 Solder Balls/Solder Fines ..... 5-14</p> <p>5.2.6.2 Bridging ..... 5-16</p> <p>5.2.6.3 Solder Webbing/Splashes ..... 5-17</p> <p>5.2.7 Disturbed Solder ..... 5-18</p> <p>5.2.8 Fractured Solder ..... 5-19</p> <p>5.2.9 Solder Projections ..... 5-20</p> <p>5.2.10 Lead Free - Fillet Lift ..... 5-21</p> <p>5.2.11 Hot Tear/Shrink Hole ..... 5-22</p> <p><b>6 Terminal Connections</b> ..... 6-1</p> <p><b>6.1 Edge Clip</b> ..... 6-2</p> <p><b>6.2 Swaged Hardware</b> ..... 6-3</p> <p>6.2.1 Rolled Flange ..... 6-4</p> <p>6.2.2 Flared Flange ..... 6-5</p> <p>6.2.3 Controlled Split ..... 6-6</p> <p>6.2.4 Terminals ..... 6-7</p> <p>6.2.4.1 Turret ..... 6-7</p> <p>6.2.4.2 Bifurcated ..... 6-8</p> <p>6.2.5 Fused in Place ..... 6-9</p> <p><b>6.3 Wire/Lead Preparation - Tinning</b> ..... 6-11</p> <p><b>6.4 Lead Forming - Stress Relief</b> ..... 6-13</p> <p><b>6.5 Service Loops</b> ..... 6-14</p>	<p><b>6.6 Terminals - Stress Relief Lead/Wire Bend</b> ..... 6-15</p> <p>6.6.1 Bundle ..... 6-15</p> <p>6.6.2 Single Wire ..... 6-16</p> <p><b>6.7 Lead/Wire Placement</b> ..... 6-17</p> <p>6.7.1 Turrets and Straight Pins ..... 6-18</p> <p>6.7.2 Bifurcated ..... 6-20</p> <p>6.7.2.1 Side Route Attachments ..... 6-20</p> <p>6.7.2.2 Bottom and Top Route Attachments ..... 6-22</p> <p>6.7.3 Staked Wires ..... 6-23</p> <p>6.7.4 Slotted ..... 6-24</p> <p>6.7.5 Pierced/Perforated ..... 6-25</p> <p>6.7.6 Hook ..... 6-26</p> <p>6.7.7 Solder Cups ..... 6-27</p> <p>6.7.8 Series Connected ..... 6-28</p> <p>6.7.9 AWG 30 and Smaller Diameter Wires ..... 6-29</p> <p><b>6.8 Insulation</b> ..... 6-30</p> <p>6.8.1 Clearance ..... 6-30</p> <p>6.8.2 Damage ..... 6-32</p> <p>6.8.2.1 Presolder ..... 6-32</p> <p>6.8.2.2 Post-Solder ..... 6-34</p> <p>6.8.3 Flexible Sleeve ..... 6-35</p> <p><b>6.9 Conductor</b> ..... 6-37</p> <p>6.9.1 Deformation ..... 6-37</p> <p>6.9.2 Strand Separation (Birdcaging) ..... 6-38</p> <p>6.9.3 Damage ..... 6-39</p> <p><b>6.10 Terminals - Solder</b> ..... 6-40</p> <p>6.10.1 Turret ..... 6-41</p> <p>6.10.2 Bifurcated ..... 6-42</p> <p>6.10.3 Slotted ..... 6-45</p> <p>6.10.4 Pierced Tab ..... 6-46</p> <p>6.10.5 Hook/Pin ..... 6-47</p> <p>6.10.6 Solder Cups ..... 6-48</p> <p><b>6.11 Conductor - Damage - Post-Solder</b> ..... 6-49</p>
---	---

## Table of Contents (cont.)

<b>7 Through-Hole Technology</b> .....	7-1	<b>7.4 Unsupported Holes</b> .....	7-33
<b>7.1 Component Mounting</b> .....	7-2	7.4.1 Axial Leads - Horizontal .....	7-33
7.1.1 Orientation .....	7-2	7.4.2 Vertical .....	7-34
7.1.1.1 Horizontal .....	7-3	7.4.3 Wire/Lead Protrusion .....	7-35
7.1.1.2 Vertical .....	7-5	7.4.4 Wire/Lead Clinches .....	7-36
7.1.2 Lead Forming .....	7-6	7.4.5 Solder .....	7-38
7.1.2.1 Bends .....	7-6	7.4.6 Lead Cutting after Soldering .....	7-41
7.1.2.2 Stress Relief .....	7-8	<b>7.5 Supported Holes</b> .....	7-41
7.1.2.3 Damage .....	7-10	7.5.1 Axial Leaded - Horizontal .....	7-41
7.1.3 Leads Crossing Conductors .....	7-11	7.5.2 Axial Leaded - Vertical .....	7-43
7.1.4 Hole Obstruction .....	7-12	7.5.3 Supported Holes -Wire/Lead Protrusion .....	7-45
7.1.5 DIP/SIP Devices and Sockets .....	7-13	7.5.4 Wire/Lead Clinches .....	7-46
7.1.6 Radial Leads - Vertical .....	7-15	7.5.5 Solder .....	7-48
7.1.6.1 Spacers .....	7-16	7.5.5.1 Vertical Fill (A) .....	7-51
7.1.7 Radial Leads - Horizontal .....	7-18	7.5.5.2 Primary Side - Lead to Barrel (B) .....	7-53
7.1.8 Connectors .....	7-19	7.5.5.3 Primary Side - Land Area Coverage (C) .....	7-55
7.1.9 High Power .....	7-21	7.5.5.4 Secondary Side - Lead to Barrel (D) .....	7-56
<b>7.2 Heatsinks</b> .....	7-23	7.5.5.5 Secondary Side - Land Area Coverage (E) .....	7-57
7.2.1 Insulators and Thermal Compounds .....	7-25	7.5.5.6 Solder Conditions - Solder in Lead Bend .....	7-58
7.2.2 Contact .....	7-26	7.5.5.7 Meniscus in Solder .....	7-59
<b>7.3 Component Securing</b> .....	7-27	7.5.5.8 Lead Cutting after Soldering .....	7-60
7.3.1 Mounting Clips .....	7-27	7.5.5.9 Coated Wire Insulation in Solder .....	7-61
7.3.2 Adhesive Bonding - Nonelevated Components .....	7-29	7.5.5.10 Interfacial Connection without Lead - Vias .....	7-62
7.3.3 Adhesive Bonding - Elevated Components .....	7-31		
7.3.4 Wire Hold Down .....	7-32		

## Table of Contents (cont.)

<b>8 Surface Mount Assemblies</b> .....	8-1	<b>8.2.5 Flat Ribbon, L, and Gull Wing Leads</b> .....	8-41
<b>8.1 Staking Adhesive</b> .....	8-3	8.2.5.1 Side Overhang (A) .....	8-41
<b>8.2 SMT Connections</b> .....	8-4	8.2.5.2 Toe Overhang (B) .....	8-45
<b>8.2.1 Chip Components - Bottom Only Terminations</b> .....	8-4	8.2.5.3 Minimum End joint Width (C) .....	8-46
8.2.1.1 Side Overhang (A) .....	8-5	8.2.5.4 Minimum Side Joint Length (D) .....	8-48
8.2.1.2 End Overhang (B) .....	8-6	8.2.5.5 Maximum Heel Fillet Height (E) .....	8-50
8.2.1.3 End Joint Width (C) .....	8-7	8.2.5.6 Minimum Heel Fillet Height (F) .....	8-51
8.2.1.4 Side Joint Length (D) .....	8-8	8.2.5.7 Solder Thickness (G) .....	8-52
8.2.1.5 Maximum Fillet Height (E) .....	8-9	8.2.5.8 Coplanarity .....	8-53
8.2.1.6 Minimum Fillet Height (F) .....	8-9	<b>8.2.6 Round or Flattened (Coined) Leads</b> .....	8-54
8.2.1.7 Solder Thickness (G) .....	8-10	8.2.6.1 Side Overhang (A) .....	8-55
8.2.1.8 End Overlap (J) .....	8-10	8.2.6.2 Toe Overhang (B) .....	8-56
<b>8.2.2 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination</b> .....	8-11	8.2.6.3 Minimum End Joint Width (C) .....	8-56
8.2.2.1 Side Overhang (A) .....	8-12	8.2.6.4 Minimum Side Joint Length (D) .....	8-57
8.2.2.2 End Overhang (B) .....	8-14	8.2.6.5 Maximum Heel Fillet Height (E) .....	8-58
8.2.2.3 End Joint Width (C) .....	8-15	8.2.6.6 Minimum Heel Fillet Height (F) .....	8-59
8.2.2.4 Side Joint Length (D) .....	8-17	8.2.6.7 Solder Thickness (G) .....	8-60
8.2.2.5 Maximum Fillet Height (E) .....	8-18	8.2.6.8 Minimum Side Joint Height (Q) .....	8-60
8.2.2.6 Minimum Fillet Height (F) .....	8-19	8.2.6.9 Coplanarity .....	8-61
8.2.2.7 Thickness (G) .....	8-20	<b>8.2.7 J Leads</b> .....	8-62
8.2.2.8 End Overlap (J) .....	8-21	8.2.7.1 Side Overhang (A) .....	8-62
8.2.2.9 Termination Variations .....	8-22	8.2.7.2 Toe Overhang (B) .....	8-64
8.2.2.9.1 Mounting on Side (Billboarding) .....	8-22	8.2.7.3 End Joint Width (C) .....	8-64
8.2.2.9.2 Mounting Upside Down .....	8-24	8.2.7.4 Side Joint Length (D) .....	8-66
8.2.2.9.3 Stacking .....	8-25	8.2.7.5 Maximum Fillet Height (E) .....	8-67
8.2.2.9.4 Tombstoning .....	8-26	8.2.7.6 Minimum Heel Fillet Height (F) .....	8-68
<b>8.2.3 Cylindrical End Cap (MELF) Termination</b> .....	8-27	8.2.7.7 Solder Thickness (G) .....	8-70
8.2.3.1 Side Overhang (A) .....	8-28	8.2.7.8 Coplanarity .....	8-70
8.2.3.2 End Overhang (B) .....	8-29	<b>8.2.8 Butt/I Connections</b> .....	8-71
8.2.3.3 End Joint Width (C) .....	8-30	8.2.8.1 Maximum Side Overhang (A) .....	8-71
8.2.3.4 Side Joint Length (D) .....	8-31	8.2.8.2 Maximum Toe Overhang (B) .....	8-72
8.2.3.5 Maximum Fillet Height (E) .....	8-32	8.2.8.3 Minimum End Joint Width (C) .....	8-72
8.2.3.6 Minimum Fillet Height (F) .....	8-33	8.2.8.4 Minimum Side Joint Length (D) .....	8-73
8.2.3.7 Solder Thickness (G) .....	8-34	8.2.8.5 Maximum Fillet Height (E) .....	8-73
8.2.3.8 End Overlap (J) .....	8-35	8.2.8.6 Minimum Fillet Height (F) .....	8-74
<b>8.2.4 Castellated Terminations</b> .....	8-36	8.2.8.7 Solder Thickness (G) .....	8-74
8.2.4.1 Side Overhang (A) .....	8-37	<b>8.2.9 Flat Lug Leads</b> .....	8-75
8.2.4.2 End Overhang (B) .....	8-38	<b>8.2.10 Tall Profile Components Having Bottom Only Terminations</b> .....	8-76
8.2.4.3 Minimum End Joint Width (C) .....	8-38	<b>8.2.11 Inward Formed L-Shaped Ribbon Leads</b> .....	8-77
8.2.4.4 Minimum Side Joint Length (D) .....	8-39	<b>8.2.12 Surface Mount Area Array</b> .....	8-79
8.2.4.5 Maximum Fillet Height (E) .....	8-39	8.2.12.1 Alignment .....	8-80
8.2.4.6 Minimum Fillet Height (F) .....	8-40	8.2.12.2 Solder Ball Spacing .....	8-80
8.2.4.7 Solder Thickness (G) .....	8-40	8.2.12.3 Solder Connections .....	8-81
		8.2.12.4 Voids .....	8-83
		8.2.12.5 Underfill/Staking .....	8-83
		<b>8.2.13 Plastic Quad Flat Pack - No Leads (PQFN)</b> .....	8-84
		<b>8.2.14 Components with Bottom Thermal Plane Terminations</b> .....	8-86

## Table of Contents (cont.)

<b>9 Component Damage</b> .....	9-1	<b>10.4 Cleanliness</b> .....	10-35
<b>9.1 Loss of Metallization &amp; Leaching</b> .....	9-2	10.4.1 Flux Residues .....	10-36
<b>9.2 Chip Resistor Element</b> .....	9-3	10.4.2 Particulate Matter .....	10-37
<b>9.3 Leaded/Leadless Devices</b> .....	9-4	10.4.3 Chlorides, Carbonates and White Residues .....	10-38
<b>9.4 Chip Components</b> .....	9-8	10.4.4 No-Clean Process - Appearance .....	10-40
<b>9.5 Connectors</b> .....	9-10	10.4.5 Surface Appearance .....	10-41
<b>10 Printed Circuit Boards and Assemblies</b> .....	10-1	<b>10.5 Coatings</b> .....	10-43
<b>10.1 Gold Fingers</b> .....	10-2	10.5.1 Solder Resist Coating .....	10-43
<b>10.2 Laminate Conditions</b> .....	10-4	10.5.1.1 Wrinkling/Cracking .....	10-44
10.2.1 Measling and Crazeing .....	10-5	10.5.1.2 Voids and Blisters .....	10-46
10.2.2 Blistering and Delamination .....	10-7	10.5.1.3 Breakdown .....	10-48
10.2.3 Weave Texture/Weave Exposure .....	10-10	10.5.1.4 Discoloration .....	10-49
10.2.4 Haloing and Edge Delamination .....	10-12	10.5.2 Conformal Coating .....	10-50
10.2.5 Pink Ring .....	10-13	10.5.2.1 General .....	10-50
10.2.6 Burns .....	10-14	10.5.2.2 Coverage .....	10-50
10.2.7 Bow and Twist .....	10-15	10.5.2.3 Thickness .....	10-53
10.2.8 Flexible and Rigid-Flex Printed Circuitry .....	10-16	<b>11 Discrete Wiring</b> .....	11-1
10.2.8.1 Nicks and Tears .....	10-16	<b>11.1 Solderless Wrap</b> .....	11-2
10.2.8.2 Stiffener Board Delamination .....	10-18	11.1.1 Number of Turns .....	11-3
10.2.8.3 Discoloration .....	10-19	11.1.2 Turn Spacing .....	11-4
10.2.8.4 Solder Wicking .....	10-20	11.1.3 End Tails, Insulation Wrap .....	11-5
10.2.9 Conductors/Lands .....	10-21	11.1.4 Raised Turns Overlap .....	11-7
10.2.9.1 Reduction in Cross-Sectional Area .....	10-21	11.1.5 Connection Position .....	11-8
10.2.9.2 Lifted Pads/Lands .....	10-22	11.1.6 Wire Dress .....	11-10
10.2.9.3 Mechanical Damage .....	10-24	11.1.7 Wire Slack .....	11-11
<b>10.3 Marking</b> .....	10-25	11.1.8 Wire Plating .....	11-12
10.3.1 Etched (Including Hand Printing) .....	10-26	11.1.9 Damaged Insulation .....	11-13
10.3.2 Screened .....	10-27	11.1.10 Damaged Conductors & Terminals .....	11-14
10.3.3 Stamped .....	10-28	<b>11.2 Jumper Wires</b> .....	11-15
10.3.4 Laser .....	10-30	11.2.1 Wire Selection .....	11-16
10.3.5 Labels .....	10-32	11.2.2 Wire Routing .....	11-17
10.3.5.1 Bar Coding .....	10-32	11.2.3 Wire Staking .....	11-20
10.3.5.2 Readability .....	10-32	11.2.4 Plated-Through Holes .....	11-22
10.3.5.3 Adhesion and Damage .....	10-33	11.2.4.1 PTH/Via - Lead in Hole .....	11-22
10.3.5.4 Position .....	10-34	11.2.4.2 PTH - Wrapped Attachment .....	11-23
		11.2.4.3 Lap Soldered .....	11-24
		11.2.5 SMT .....	11-26
		11.2.5.1 Chip and Cylindrical End Cap Components ..	11-26
		11.2.5.2 Gull Wing .....	11-27
		11.2.5.3 J Lead .....	11-28
		11.2.5.4 Vacant Land .....	11-28
		<b>11.3 Component Mounting - Connector</b>	
		<b>Wire Dress Strain/Stress Relief</b> .....	11-29

## Table of Contents (cont.)

<b>12 High Voltage</b> .....	12-1	Table 7-5	Protrusion of Leads in Supported Holes ...	7-45
<b>12.1 Terminals</b> .....	12-2	Table 7-6	Plated-Through Holes with Component Leads - Minimum Acceptable Solder Conditions .....	7-50
12.1.1 Wires/Leads .....	12-2			
12.1.2 Bottom Terminations .....	12-4			
12.1.3 Terminals - Unused .....	12-5	Table 7-7	Plated-Through Holes with Component Leads - Intrusive Soldering Process - Minimum Acceptable Solder Conditions ...	7-50
<b>12.2 Solder Cups</b> .....	12-6	Table 8-1	Dimensional Criteria - Chip Component - Bottom Only Termination Features .....	8-4
12.2.1 Wires/Leads .....	12-6			
12.2.2 Unused .....	12-7			
<b>12.3 Insulation</b> .....	12-8	Table 8-2	Dimensional Criteria - Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Terminations .....	8-11
<b>12.4 Through-Hole Connections</b> .....	12-9	Table 8-3	Dimensional Criteria - Cylindrical End Cap (MELF) Termination .....	8-27
<b>12.5 Flared Flange Terminals</b> .....	12-10	Table 8-4	Dimensional Criteria - Castellated Terminations .....	8-36
<b>12.6 Other Hardware</b> .....	12-11	Table 8-5	Dimensional Criteria - Flat Ribbon, L, and Gull Wing Leads .....	8-41
<b>Appendix A Electrical Conductor Spacing</b> .....	A-1	Table 8-6	Dimensional Criteria - Round or Flattened (Coined) Lead Features .....	8-54
<b>Index</b> .....	Index-1	Table 8-7	Dimensional Criteria - "J" Leads .....	8-62
		Table 8-8	Dimensional Criteria - Butt/I Connections (Not Applicable to Class 3) .....	8-71
		Table 8-9	Dimensional Criteria - Flat Lug Leads .....	8-75
		Table 8-10	Dimensional Criteria - Tall Profile Components Having Bottom Only Terminations .....	8-76
		Table 8-11	Dimensional Criteria - Inward Formed L-Shaped Ribbon Leads .....	8-77
		Table 8-12	Dimensional Criteria - Surface Mount Area Array Features .....	8-79
		Table 8-13	Dimensional Criteria - PQFN .....	8-84
		Table 8-14	Dimensional Criteria - Bottom Thermal Plane Terminations .....	8-86
		Table 9-1	Chip-Out Criteria .....	9-8
		Table 10-1	Coating Thickness .....	10-53
		Table 11-1	Minimum Turns of Bare Wire .....	11-3

### TABLES

Table 1-1	Summary of Related Documents .....	1-2
Table 1-2	Inspection Magnification (Land Width) .....	1-6
Table 1-3	Magnification Aid Applications - Other .....	1-6
Table 3-1	Typical Static Charge Sources .....	3-4
Table 3-2	Typical Static Voltage Generation .....	3-4
Table 3-3	Maximum Allowable Resistance and Discharge Times for Static Safe Operations .....	3-7
Table 3-4	Recommended Practices for Handling Electronic Assemblies .....	3-9
Table 4-1	Minimum Bend Radius Requirements .....	4-25
Table 6-1	Allowable Strand Damage .....	6-39
Table 7-1	Minimum Inside Bend Radius .....	7-6
Table 7-2	Protrusion of Leads in Unsupported Holes .....	7-35
Table 7-3	Unsupported Holes with Component Leads, Minimum Acceptable Conditions .....	7-38
Table 7-4	Component to Board Clearance .....	7-43

# 1 Acceptability of Electronic Assemblies

## Foreword

The following topics are addressed in this section:

### 1.1 Scope

### 1.2 Purpose

### 1.3 Specialized Designs

### 1.4 Terms & Definitions

- 1.4.1 Classification
  - Class 1 – General Electronic Products
  - Class 2 – Dedicated Service Electronic Products
  - Class 3 – High Performance Electronic Products
- 1.4.2 Acceptance Criteria
  - 1.4.2.1 Target Condition
  - 1.4.2.2 Acceptance Condition
  - 1.4.2.3 Defect Condition
  - 1.4.2.4 Process Indicator Condition
  - 1.4.2.5 Combined Conditions
  - 1.4.2.6 Conditions Not Specified

- 1.4.3 Board Orientation
  - 1.4.3.1 \*Primary Side
  - 1.4.3.2 \*Secondary Side
  - 1.4.3.3 Solder Source Side
  - 1.4.3.4 Solder Destination Side
- 1.4.4 \*Cold Solder Connection
- 1.4.5 Electrical Clearance
- 1.4.6 High Voltage
- 1.4.7 Intrusive Solder
- 1.4.8 \*Leaching
- 1.4.9 Meniscus (Component)
- 1.4.10 Pin-in-Paste
- 1.4.11 Wire Diameter

### 1.5 Examples and Illustrations

### 1.6 Inspection Methodology

### 1.7 Verification of Dimensions

### 1.8 Magnification Aids and Lighting



## Foreword

**If a conflict occurs between the English and translated versions of this document, the English version will take precedence.**

### 1.1 Scope

This standard is a collection of visual quality acceptability requirements for electronic assemblies.

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, IPC-HDBK-610, and IPC J-STD-001.

The criteria in this standard are not intended to define processes to accomplish assembly operations nor is it intended to authorize repair/modification or change of the customer's product. For instance, the presence of criteria for adhesive bonding of components does not imply/authorize/require the use of adhesive bonding, and the depiction of a lead wrapped clockwise around a terminal does not imply/authorize/require that all leads/wires be wrapped in the clockwise direction.

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

**Table 1-1 Summary of Related Documents**

Document Purpose	Spec.#	Definition
Design Standard	IPC-2220 (Series) IPC-SM-782 IPC-CM-770	Design requirements reflecting three levels of complexity (Levels A, B, and C) indicating finer geometries, greater densities, more process steps to produce the product.  Component and Assembly Process Guidelines to assist in the design of the bare board and the assembly where the bare board processes concentrate on land patterns for surface mount and the assembly concentrates on surface mount and through-hole principles which are usually incorporated into the design process and the documentation.
End Item Documentation	IPC-D-325	Documentation depicting bare board specific end product requirements designed by the customer or end item assembly requirements. Details may or may not reference industry specifications or workmanship standards as well as customer's own preferences or internal standard requirements.
End Item Standards	IPC J-STD-001	Requirements for soldered electrical and electronic assemblies depicting minimum end product acceptable characteristics as well as methods for evaluation (test methods), frequency of testing and applicable ability of process control requirements.
Acceptability Standard	IPC-A-610	Pictorial interpretive document indicating various characteristics of the board and/or assembly as appropriate relating to desirable conditions that exceed the minimum acceptable characteristics indicated by the end item performance standard and reflect various out-of-control (process indicator or defect) conditions to assist the shop process evaluators in judging need for corrective action.
Training Programs (Optional)		Documented training requirements for teaching and learning process procedures and techniques for implementing acceptance requirements of either end item standards, acceptability standards, or requirements detailed on the customer documentation.
Rework and Repair	IPC-7711A/ IPC-7721A	Documentation providing the procedures to accomplish conformal coating and component removal and replacement, solder resist repair, and modification/repair of laminate material, conductors, and plated-through holes.

## Foreword (cont.)

IPC-HDBK-610 is a supporting document that provides information regarding the intent of this specification content and explains or amplifies the technical rationale for transition of limits through Target to Defect condition criteria. In addition, supporting information is provided to give a broader understanding of the process considerations that are related to performance but not commonly distinguishable through visual assessment methods.

The explanations provided in this companion resource should be useful in determining disposition of conditions identified as Defect, processes associated with Process Indicators, as well as answering questions regarding clarification in use and application for defined content of this specification. Contractual reference to this standard does not additionally impose the content of IPC-HDBK-610 unless specifically referenced in contractual documentation.

### 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-2220 (Series), IPC-6010 (Series) and IPC-A-600. If the assembly does not comply with these or with equivalent requirements, 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.***

### 1.3 Specialized Designs

IPC-A-610, as an industry consensus document, cannot address all of the possible components and product design combinations. Where uncommon or specialized technologies are used, it may be necessary to develop unique acceptance criteria. 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 and, for Class 3, needs to have customer consent, and the criteria should include agreed definition of product acceptance.

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

### 1.4 Terms & Definitions

Items noted with an \* are quoted from IPC-T-50.

#### 1.4.1 Classification

**The customer (user) has the ultimate responsibility for identifying the class to which the assembly is evaluated.**

Documentation that specifies the applicable class for the assembly under inspection needs to be provided to the inspector.

Accept and/or reject decisions need to be based on applicable documentation such as contracts, drawings, specifications, standards and reference documents. Criteria defined in this document reflect three classes, which are as follows:

#### Class 1 — General Electronic Products

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

#### Class 2 — Dedicated Service Electronic Products

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

#### Class 3 — High Performance Electronic Products

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

#### 1.4.2 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 IPC 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 supplier.
2. Master drawing or master assembly drawing reflecting the customer's detailed requirements.