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• 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

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• 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

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Thank you for your continued support.
Developed by the Telecom IPC-A-610 Addendum Task Group (7-31bc) of the Product Assurance Committee (7-30) of IPC

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

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Acknowledgment

Members of the Telecom IPC-A-610 Addendum Task Group have worked together to develop this document. We would like to thank them for their dedication to this effort. Any document involving a complex technology draws material from a vast number of sources. While the principal members of the Telecom IPC-A-610 Addendum Task Group (7-31bc) 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.

<table>
<thead>
<tr>
<th>Product Assurance Committee</th>
<th>IPC-A-610 Telecom Addendum Task Group</th>
<th>Technical Liaisons of the IPC Board of Directors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chair</td>
<td>Chair</td>
<td>Peter Bigelow</td>
</tr>
<tr>
<td>Mel Parrish</td>
<td>Darrin Dodson</td>
<td>IMI Inc.</td>
</tr>
<tr>
<td>STI Electronics</td>
<td>Alcatel-Lucent</td>
<td>Sammy Yi</td>
</tr>
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<td></td>
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<td>Aptina Imaging Corporation</td>
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</tbody>
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Members of the IPC-A-610 Telecom Addendum Task Group

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Bob Willis, The SMART Group

SPECIAL ACKNOWLEDGMENT

We would like to provide special acknowledgment to the following member for providing pictures and illustrations that are used in this revision.

Darrin Dodson, Alcatel-Lucent
0.1 **Scope** This addendum provides requirements to be used in addition to, and in some cases, in place of, those published in IPC-A-610D to ensure that electrical and electronic assemblies meet requirements for customers requiring Telecordia GR-78-CORE compliance.

Where content criteria are not supplemented, the Class 2 requirements of IPC-A-610D apply.

0.1.1 **Purpose** When required by procurement documentation/drawings, this Addendum supplements or replaces specifically identified requirements of IPC-A-610D.

0.1.2 **Precedence** Customer contractual requirements take precedence over this Addendum, referenced standards and user-approved drawings. In the event of a conflict between this Addendum and the applicable documents cited herein, this Addendum takes precedence. Where referenced criteria of this addendum differ from the published IPC-A-610D, this addendum takes precedence.

0.1.3 **Existing or Previously Approved Designs** This Addendum shall not constitute the sole cause for the redesign of previously approved designs. When drawings for existing or previously approved designs undergo revision they should be reviewed and changes made that allow for compliance with the requirements of this Addendum.

0.1.4 **Use** This Addendum is applicable for rigid single sided, double sided, and multilayer boards.

This Addendum shall not to be used as a standalone document.

Where criteria are not supplemented, the Class 2 requirements of IPC-A-610D apply. Criteria defined in IPC-A-601D as “process defects” for class 2 shall be treated as defective, unless otherwise stated in this Addendum.

If an IPC-A-610D requirement is changed or added by this Addendum, the clause is identified and that entire IPC-A-610D clause or subordinate clause is replaced by the criteria in this Addendum.

The clauses modified by this Addendum do not include subordinate clauses unless specifically stated (e.g., 1.4 does not include 1.4.1). Clauses, Tables, Figures, etc., in IPC-A-610D that are not listed in this Addendum are to be used as-published.

In this addendum, as in the published IPC-A-610D, in case of conflict or discrepancy, the description or written criteria always take precedence over the illustrations.

The surface insulation resistance and the electromigration resistance of the finished PBA shall be in accordance with GR-78-CORE. This is relevant for no-clean assembly processes, which should be used preferably, as well as for fluxes which are intended to be cleaned, and for SMC adhesives.

Solder alloy shall comply with J-STD-006 or equivalent.

0.1.5 **Additional Referenced Standards** Telecordia GR-78-CORE Generic Requirements for the Physical Design and Manufacture of Telecommunications Products and Equipment (http://telecom-info.telcordia.com).
1.4.5 Electrical Clearance

These criteria replace all of 1.4.5 in published IPC-A-610D.

Minimum electrical clearance for products built to this document is specified as 0.13 mm (.005 in).

4.1.3 Hardware Installation – Threaded Fasteners

These criteria replace all of 4.1.3 in published IPC-A-610D.

**Defect**
- Less than one and one-half thread extends beyond the threaded hardware, (e.g., nut) unless thread extension would interfere with other component.
- Thread extension more than 3 mm (.12 in) plus one and one-half threads for bolts or screws up to 25 mm (.984 in).
- Thread extension more than 6.3 mm (.248 in) plus one and one-half threads for bolts or screws over 25 mm (.984 in).
- Bolts or screws without locking mechanisms.

4.1.3.1 Hardware Installation – Threaded Fasteners – Torque

These criteria replace all of 4.1.3.1 in published IPC-A-610D.

When 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. Fastener torque value, if not specified, **shall** be specified by engineering documentation.

**Acceptable**
- Fasteners are tight and split-ring lock washers, when used, are fully compressed.
- Fasteners torque values are within the limits as specified by drawing, or as specified by engineering documentation.

**Defect**
- Split-ring lock washer not compressed.
- Fasteners are not properly torqued within the limits specified by drawing, or as specified by engineering documentation.

4.1.3.2 Hardware Installation – Threaded Fasteners – Wires

Criteria in published IPC-A-610D 4.1.3.2 are not applicable to users of this addendum.
These criteria replace all of 4.3.2 in published IPC-A-610D.

**Acceptable**
- Damaged nonfunctional lands for single and double-sided boards are acceptable if firmly attached to board in unlifted areas.

**Defect**
- Any functional annular ring which is lifted.

These criteria replace all of 4.4.1 in published IPC-A-610D.

Metal cable clamps **shall not** be used unless they are insulated.

**Acceptable**
- The wires are secured in the wire bundle.
- Cable ties are cut flush with the locking head.

**Defect**
- Spot tie wrap or knot is loose.
- Wire bundle is loose.
- Cable tied with an improper knot. This tie may eventually loosen.
- Restraining devices, clamps, plastic ties, lacing cord, etc. damages the wiring insulation or cable by compression.
- End of cut tie wrap protrudes past the face of the locking head.

This replaces Table 4-1 in 4.5.2 of published IPC-A-610D. All of the rest of 4.5.2 in published IPC-A-610D is applicable.

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>IPC-A-610DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare bus or enamel insulated wire</td>
<td>2X</td>
</tr>
<tr>
<td>Insulated wire and flat ribbon cable</td>
<td>2X</td>
</tr>
<tr>
<td>Cable bundles with no coax cables</td>
<td>2X</td>
</tr>
<tr>
<td>Cable bundles with coax cables</td>
<td>5X</td>
</tr>
<tr>
<td>Coaxial cables</td>
<td>5X</td>
</tr>
<tr>
<td>CATS Ethernet cable</td>
<td>4X</td>
</tr>
<tr>
<td>Fiber Optic Cable - Buffered and Jacketed Single Fiber</td>
<td>1 inch or as specified by the manufacturer</td>
</tr>
<tr>
<td>Larger jacketed fibers</td>
<td>15X cable diameter or as specified by the manufacturer</td>
</tr>
</tbody>
</table>
These criteria replace all of 4.5.3 in published IPC-A-610D.

**Defect**
- Inside bend radii does not meet the criteria of Table 4-1.

**Defect**
- Spot ties or tie wraps that cause any deformation of coaxial cables.

**5.2.1 Soldering Anomalies – Exposed Basis Metal**

These criteria replace all of 5.2.1 in published IPC-A-610D.

**Process Indicator**
- Exposed basis metal on component leads, conductors or land surfaces from nicks or scratches provided conditions do not exceed the requirements of 7.1.2.3 for leads and 10.2.9.1 for conductors and lands.

**5.2.2 Soldering Anomalies – Pin Holes/Blow Holes**

These criteria replace all of 5.2.2 in published IPC-A-610D.

**Process Indicator**
- Blowholes, pinholes, voids, etc., providing the solder connection meets all other requirements.

**7.1 Component Mounting**

Use 7.1 published criteria in IPC-A-610D with this added statement:

The presence of engineering approved spacers or insulators, used to improve manufacturability, **shall not** be cause for rejection.
7.1.7 Component Mounting – Radial Leads – Horizontal

These criteria replace all of 7.1.7 in published IPC-A-610D.

**Target**
- The component body is in flat contact with the board’s surface.

**Acceptable**
- Component in contact with board on at least one side and/or surface.

**Note:** When documented on an approved assembly drawing, a component may be either side mounted or end mounted. The side or surface of the body, or at least one point of any irregularly configured component (such as certain pocketbook capacitors), needs to be in full contact with the printed board.

The body **shall** be bonded or otherwise secured to the board to prevent damage when vibration and shock forces are applied.

**Defect**
- Component not secured.

7.1.8 Component Mounting – Connectors

These criteria replace all of 7.1.8 in published IPC-A-610D.

These criteria apply to soldered connectors and unsoldered press fit connectors. For connector pin criteria see 4.3. For connector damage criteria see 9.5.

Connector module/pin misalignment, defined in this section, is to be measured at the connector lead-in area/hole (for receptacles) or at the pin tip (for pin headers).

In cases where an assembly connector is composed of two or more identical connector modules, it **shall not** be permissible to mix modules manufactured by different suppliers.
7.1.8.1 Connector Mounting – Heat Staking

Added criteria in this addendum.

Heat Stake/Press Peg Appearance  After heat staking, the heat staked heads **shall** meet the requirements shown on Figure 7-1 of this specification.

- The heat staked heads **shall not** have any loose flash or loose fractured pieces.
- PWB conductor paths and solder-resist areas adjacent to the heat staked heads **shall not** be damaged by the heat staking process.

Missing or Nonconforming Heat Stakes  On any connector, heat stakes (press pegs) may be missing or not conforming to the requirements provided that they are not higher than 1.6 mm [0.062 in] above the PWB, and each nonconforming heat stake (press peg) is bounded on either side by two heat stakes (press pegs) that are conforming. The outer two heat stakes (press pegs) on either end of the connector must conform to production requirements.

**Figure 7-1**
A. 1.680 ± 0.20 mm max. height  
B. Max. diameter of 4.0 ± 0.2 mm

**Figure 7-2**
Acceptable

- ≥50% of the heat stake is present.
- No loose or fractured flash pieces.

Defect

- <50% of the heat stake is present.
- Loose flashing from heat stake process (see Figure 7-5).
7.1.8.1 Connector Mounting – Heat Staking (cont.)

Figure 7-5

7.1.8.2 Connector Mounting – Soldered Connectors – Right Angle – Pin Spacing ≥2.5 mm [0.098 in]

Added criteria in this addendum.

Target

- Connector is mounted flush with the surface of the board.

Acceptable

- Connector-to-board spacing is equal to or less than 0.25 mm [0.010 in] (not shown).

Defect

- Connector to board spacing is greater than 0.25 mm [0.010 in] (not shown).

Figure 7-6
Added criteria in this addendum.

**Target**
- Connector is mounted flush with the surface of the board (A).
- All modules of a multi-part connector are aligned and are mounted flush to adjoining modules (B).

**Acceptable**
- Connector-to-board spacing is equal to or less than 0.13 mm [0.005 in] (not shown).
- Maximum misalignment is ≤0.25 mm [0.010 in] across the faces (contact openings) of all modules (connectors) in the connector lineup (see Figure 7-8(A)).

**Defect**
- Connector-to-board spacing is greater than 0.13 mm [0.005 in] (not shown).
- Maximum misalignment is >0.25 mm [0.010 in] across the faces (contact openings) of all modules (connectors) in the connector lineup (see Figure 7-8(A)).
Added criteria in this addendum.

Target
- Connector is mounted flush with the surface of the board.
- All modules of a multi-part connector are aligned and are mounted flush to adjoining modules (not shown).

Acceptable
- Connector-to-board spacing is equal to or less than 0.13 mm [0.005 in] (not shown).
- Individual module contact openings, requiring alignment, are equal to, or less than, 0.25 mm [0.010 in], with adjacent modules (not shown). Maximum misalignment between any two modules/pins in the connector lineup is ≤0.25 mm [0.010 in] (not shown).

Defect
- Connector-to-board spacing is greater than 0.13 mm [0.005 in].
- Maximum misalignment between any two modules/pins in the connector lineup is >0.25 mm [0.010 in] (not shown).
Added criteria in this addendum.

### 7.1.8.5.1 Connector Mounting – Compliant Pin Connectors – Pin Spacing ≥2.5 mm

**Target**
- Connector is mounted flush with the surface of the board.

**Acceptable**
- Connector-to-board separation is less than or equal to 0.25 mm [0.010 in] (not shown).
- Connector tail pins protrude through, or are flush with, the surface of the board (not shown).
- Connector tail pins are of equal length from pin to pin within the same row (not shown).

**Defect**
- Connector-to-board separation is greater than 0.25 mm [0.010 in].
- Connector tail pins do not protrude through, or are not flush with, the surface of the board (not shown).
- Connector tail pins are not of equal length from pin to pin within the same row (not shown).
Added criteria in this addendum.

**Target**
- Connector is mounted flush with the surface of the board.
- Connector pins of similar modules are of equal length from pin to pin within the same row.
- Shield (if applicable) is installed according to the fabrication design requirements (see Figure 7-14).
- All modules of a multi-part connector are aligned and are mounted flush to adjoining modules (see Figure 7-15).

Figure 7-13

Figure 7-14

Figure 7-15
7.1.8.5.2 Connector Mounting – Compliant Pin Connectors – Right Angle, Pin Spacing ≤2.5 mm (cont.)

Acceptable

- Connector-to-board spacing is equal to or less than 0.13 mm [0.005 in] (see Figure 7-16).
- Maximum misalignment is ≤0.25 mm [0.010 in] across the faces (contact openings) of all modules (connectors) in the connector lineup (see Figure 7-17).
- Connector tail pins protrude through, or are flush with, the surface of the board.
- Connector tail pins of similar modules are of equal length from pin to pin within the same row.

Defect

- Connector-to-board spacing is greater than 0.13 mm [0.005 in] (see Figure 7-18).
- Maximum misalignment is >0.25 mm [0.010 in] across the faces (contact openings) of all modules (connectors) in the connector lineup.
- Connector tail pins do not protrude through, or are not flush with, the surface of the board.
- Connector tail pins of similar modules are not of equal length from pin to pin within the same row.
7.1.8.5.3 Connector Mounting – Compliant Pin Connectors – Vertical Shrouded Pin Headers and Vertical Receptacle Connectors (2 mm - 2.54 mm Pin Spacing)

Added criteria in this addendum.

Target
- Connector is mounted flush with the surface of the board.
- All modules/pins of a multi-part connector are aligned and are mounted flush to adjoining modules.

Acceptable
- Connector-to-board spacing (A) is equal to or less than 0.13 mm [0.005 in] from any edge or corner (not shown).
- Connector tail pins protrude through the board and are of equal length from pin to pin (not shown). (This is not applicable when design, PCB thickness or length of specified component leads prevents pin protrusion.)
- Maximum misalignment between any two modules/pins in the connector lineup is ≤0.25 mm [0.010 in] (not shown).

Defect
- Connector-to-board spacing is greater than 0.13 mm [0.005 in] at any edge or corner (not shown).
- Connector tail pins do not protrude through the board (not shown).
- Connector pins protruding through the board are not of equal length from pin to pin (not shown).
- Maximum misalignment between any two modules/pins in the connector lineup is >0.25 mm [0.010 in].
7.1.10 Component Mounting – Front Panel Mounted LEDs

Added criteria in this addendum.

There are no illustrations for these criteria.

Target

- Through-hole mounted LEDs are centered in the mounting hole.
- The tops of through-hole mounted LEDs protrude from the surface of the panel.

Acceptable

- The tops of through-hole mounted LEDs are flush with the surface of the panel.
- Three or more LEDs mounted in a row on a panel are aligned center to center and height.

Defect

- Front panel mounted LEDs are recessed below the surface of the panel.

7.1.11 Component Mounting – Conductive Cases

Added criteria in this addendum.

Where a potential for shorting (violation of minimum electrical clearance) exists between conductive component bodies, at least one of the bodies will be protected by an insulator.

7.5.1 Supported Holes – Axial Leaded – Horizontal

These criteria replace all of 7.5.1 in published IPC-A-610D.

Defect

- Component height exceeds user-determined dimension (H).
- Components dissipating greater than 1 Watt are mounted less than 1.5 mm [0.059 in] above the board surface.

7.5.5.1 Supported Holes – Solder – Vertical fill (A)

These criteria replace all of 7.5.5.1 in published IPC-A-610D.

Where large areas of copper (e.g., ground or power planes) or other heat sinks (e.g., heavy component leads) are connected to PTHs in PCBs, or where pin-in-paste processes are used on thick PCBs results in insufficient vertical solder fill and/or secondary side land wetting, hole fill shall be sufficient to ensure that the minimum pin-wetted length within the barrel is at least .047 inch regardless of board thickness.
7.5.5.7 Supported Holes – Solder Conditions – Meniscus in Solder

These criteria replace all of 7.5.5.7 in published IPC-A-610D.

- **Defect**
  - Does not meet requirements of Tables 7-6 or 7-7.
  - Coating meniscus is in the plated through hole.
  - Coating meniscus is embedded in the solder connection.

8.2 SMT Connections

These criteria replace all of 8.2 in published IPC-A-610D.

SMT connections must meet the criteria of 8.2.1 through 8.2.14, as appropriate.

Where a potential for shorting (violation of minimum electrical clearance) exists between conductive component bodies, at least one of the bodies will be protected by an insulator.

9.5.1 Component Damage – Connectors – Keys

Added criteria in this addendum.

- **Acceptable**
  - Keying slots or holes are free of cracks, chips, or foreign material that could interfere with the mating pin, blade, or alignment device (not shown).

- **Defect**
  - Keying slots or holes have cracks, chips, or foreign material that interferes with the mating pin, blade, or alignment device (not shown).

Some connectors, e.g., FutureBus®, have key tabs where keys may be inserted. To prevent damage during handling of the finished circuit pack, it is permissible to remove the key tabs at the extreme ends of the connector line-up (A) after the connectors are installed. In addition, a maximum of two (2) additional key tabs may be removed (if damaged during subsequent handling) provided that the following criteria are met:

- Broken tabs are trimmed flush to the connector body.
- Two (2) missing tabs are not next to each other on a given module.
- Two (2) missing tabs are not the end tabs on adjacent connector modules (A).
- Tabs that secure required keys shall not be damaged.
9.5.1 Component Damage – Connectors – Keys (cont.)

Acceptable
• Any removed tab is trimmed flush.

Figure 9-2

Defect
• Tab not trimmed flush to connector body.

Figure 9-3

9.5.2 Component Damage – Connectors – Surface Damage

Added criteria in this addendum.

Acceptable
• Chips, burn blemishes, or handling damage on connector surface do not extend into the contact lead-in surface.

Figure 9-4
Acceptable

- At the rate of one per assembly, the connector shield attachment device or retaining method may be damaged or missing provided that all of the following conditions are met:
  - It is not the first or last such device located at either end of the individual module.
  - The shield is adequately secured and does not interfere with alignment or prevent mating with shrouded pin header contacts.
  - The retaining device is flush or below flush with the connector housing.

Defect

- Chips, burns, or handling damage on connector surface, which extends into the contact lead-in surface.
- Connector body is damaged/deformed.
- The shield is not adequately secured and/or interferes with the alignment or prevents mating with shrouded pin header contacts (see Figure 9-8).
- The number of damaged connector shield attachment devices or retaining methods exceeds one per assembly (not shown).
- The retaining device is not flush or below flush with the connector housing (not shown).
For electrically enhanced (EE) connectors, it shall be permissible to have three (3) missing ground contacts on the bottom side per PWB provided the following criteria are met:

- Damaged ground contacts shall be trimmed flush to the ground shield (see Figure 9-10).
- Only one (1) missing ground contact per connector module is allowed.
- No damage to the top-side ground contacts is permitted.
Added criteria in this addendum.

**Acceptable**
- Minor scratches, cuts, chips, or other imperfections that do not penetrate the case or affect the seal (not shown).

**Defect**
- Scratches, cuts, chips, or other imperfections that penetrate the case or affect the seal (A, B).
- The case is bulging or swollen (C).

---

**Figure 9-11**
Added criteria in this addendum.

**Acceptable**
- Chips and/or scratches on exterior edges of core are permissible, providing they do not extend into core mating surfaces and do not exceed 1/2 the thickness of the core.

**Defect**
- Chip in the core material is located on mating surface.
- Chip extending greater than 50% of the core thickness.
- Cracks in the core material.
These criteria replace all of 10.1 in published IPC-A-610D.

The term contact area is defined as the area that encompasses all points that could be contacted by the mating connector contacts under all tolerance conditions. This includes the area from the edge of the PCB to the fully mated contact position, but excludes copper exposed by chamfering the leading edge of the PCB.

Gold plating **shall** normally extend 0.51 mm [0.020 in] above the shoulder of the contact. In situations where an extension would include holes in the gold plated area, the gold plating line **shall** end just below the pad of the hole. A demarcation line showing copper and/or discolored tin-lead **shall not** exceed 0.051 mm [0.002 in].

For the purpose of interpreting requirements on defects and surface variations on the gold-plated surface of a connector finger (see Figure 10-1), the following definitions **shall** apply:

**Pits:** A pit is a sharply defined depression in the gold-plated surface that does not extend through the underlying copper.

**Indentations:** An indentation is a gradual depression in the gold-plated surface resulting from a shallow imperfection in the underlying material. An indentation has no discernible sharp or jagged edges.

**Scratches:** A gold scratch is an abrasion in the gold-plated surface that alters or removes the gold plate and produces either exposed copper or nickel, or sharp, jagged edges. However, abrasions that merely mar or polish (buff) the gold-plated surfaces are not considered scratches.

**Pores:** A pore is any defect other than a pit or a scratch in the gold surface that exposes the underlying copper or nickel.

**Pinholes:** A pinhole is any defect that extends through the underlying copper to the base material. A pinhole may or may not be gold plated.

**Nodules:** A nodule is a volume of metal, generally round or elongated as a ridge, which projects above the surrounding gold surface. When nodules are very small and numerous, they may appear as dark or brownish gold due to their effect on reflectivity.
10.1 Gold Fingers (Contact Fingers) (cont.)

Nickel, gold, or other contact metal plating, **shall not** be applied over solder on contact fingers. Contact plating on circuits and vias in the demarcation area is not cause for rejection.

Solder spots, smears, or other contaminants, visible with 1.75X magnification are not acceptable. 4X magnification may be used for referee purposes.

Isolated conditions, including but not limited to indentations, nicks, scratches or pits in the contact area of gold fingers, **shall not** expose base metal or under-plate.

Minor test probe indentations are acceptable provided the laminate, copper or nickel is not exposed and their maximum diameter does not exceed 0.25 mm [0.010 in].

No more than 5% of the finger width of an edge board contact may be removed when drilled holes are used to remove plating bars between gold fingers. Loss of adhesion of the metallization or residual burrs is not acceptable.

Repair of gold plating **shall** meet all requirements of this specification.

Replacement of gold fingers is not allowed.

Clean areas have the same dimensional requirements as contact areas. Clean areas **shall** be free from all labels, stamps, foreign material, solder traces, planes, silk screens, reference designators, or other material that could contaminate the contacts.

Criteria listed are not required for unused contacts.

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**Figure 10-2**

A. 6.35 mm [0.25 in]
B. 0.125 mm [0.005 in]
C. Contact area

**Figure 10-3**

**Target**
- No solder or foreign material on gold surface.

**Acceptable**
- Contact plating is smooth and of uniform color (not shown).

**Defect**
- Violations of the above acceptable criteria (not shown).
10.2.1 Laminate Conditions – Measling and Crazing

These criteria replace all of 10.2.1 in published IPC-A-610D.

Target
• No evidence of measling.

Acceptable
• Measled areas in laminate substrates do not exceed 50% of the physical spacing between internal conductors.

Defect
• Measled areas in laminate substrates exceed 50% of the physical spacing between internal conductors.

Note: This document takes exception to the bare board measling criteria of some versions of IPC-A-600 and IPC-6012.

10.2.3 Laminate Conditions – Weave Texture/Weave Exposure

These criteria replace all of 10.2.3 in published IPC-A-610D.

Acceptable
• No weave exposure.

Defect
• Weave exposure is not acceptable.

10.2.9.2 Printed Circuit Boards – Pad Damage

These criteria replace all of 10.2.9.2 in published IPC-A-610D.

Acceptable
• Separation between outer edge of conductor, pad or land and laminate surface is less than one pad thickness.

Note: Lifted and/or separated land area(s) is typically a result of the soldering process that warrants immediate investigation to determine root cause. Efforts to eliminate and/or prevent this condition should be made.
These criteria replace all of 10.3 in published IPC-A-610D.

**Acceptable**
- Required marking is present.
- Marking is legible at a viewing distance of 460 mm [18 in].

**Defect**
- Required marking is not present.
- Marking is not legible.
- Marking cannot be read at a viewing distance of 460 mm [18 in].

---

**10.3.3 Marking – Stamped**

These criteria replace all of 10.3.3 in published IPC-A-610D.

**Acceptable**
- Lines of a number or letter may be broken (or the ink thin over a portion of the character) providing the breaks do not make the markings illegible.
- The open areas within characters may be filled providing the characters are legible, i.e., cannot be confused with another letter or number.

**Defect**
- Marking ink is present on the land interfering with the solder requirements of Tables 7-3, 7-6 or 7-7 or with the surface mount soldering requirements of Section 8.
- Marking inks form a conductive path that violates minimum electrical clearance.

**Acceptable**
- Marking that has been smeared or blurred but is still legible.
- Double stamped markings are acceptable provided the general intent can be determined.
- Missing or smeared marking does not exceed 10% of the character and the character is still legible.

Note: Acceptance stamp impressions do not need to be legible as long as the intent of the stamp can be determined and the operation/approval is recorded electronically.
These criteria replace all of 10.3.5.3 in published IPC-A-610D.

Acceptable

- Adhesion is complete, shows no sign of damage or peeling.

Defect

- Label is peeling.
- Missing labels.
- Label wrinkle affects readability.
- Labels are not positioned according to engineering documentation or labels that are not consistent, square, parallel, or centered.
- Labels are not readable in the finished assembly.
- Labels or markings obscure other markings or identifications.
- Labels or markings damage the underlying surface, create conductive paths, or affect the utility of the product.
- Labels are placed in areas where they are susceptible to damage.
- Wrap-around cable labels do not wrap completely around the cable.
- Wrap-around labels where the clear over-wrap portion does not completely cover the markings.
- Cable marking bands create a safety hazard (burrs, sharp edges) or a potential for electrical shorts.
- Tie-on labels are held in place with conductive materials.
- Tie-on labels restrict access or visibility to marking information or cause problems with entanglement with other assemblies.
- Labels replaced by putting one label on top of another.
These criteria replace all of 11.1.4 in published IPC-A-610D.

Raised turns are squeezed out of the helix and therefore no longer have intimate contact with the terminal corners. Raised turns may overlap or override other turns.

**Target**
- No raised turns.

**Acceptable**
- Raised turns anywhere provided remaining total turns still have contact and meet minimum turns requirement.
- No more than half turn raised within countable turns, any amount elsewhere.
- No raised turns within countable turns, any amount elsewhere.
- No overlap of turns.

**Defect**
- Any raised turns within countable turns.
- Any overlap within turns.
These criteria replace all of 11.2 in published IPC-A-610D.

These criteria do not constitute authority for repair to assemblies without prior customer consent; see 1.1. This section establishes visual acceptability criteria for the installation of discrete wires (jumper wires, haywires, etc.) used to interconnect components where there is no continuous printed circuit.

The requirements relative to wire type, wire routing, staking and soldering requirements are the same for both haywires and jumper wires. For the sake of simplicity only the more common term, jumper wires, is used in this section, however these requirements would apply to both haywires and jumper wires.

Methods described in this section apply to both modification and repair.

The following items are addressed:
- Wire type
- Wire routing
- Adhesive staking of wire
- Solder termination

They may be terminated in plated holes, and/or to terminal standoffs, conductor lands, and component leads.

Jumper wires are considered as components and are covered by an engineering instruction document for routing, termination, staking and wire type.

Keep jumper wires as short as practical and unless otherwise documented do not route over or under other replaceable components.

Design constraints such as real estate availability and minimum electrical clearance need to be taken into consideration when routing or staking wires. A jumper wire 25 mm [0.984 in] maximum in length whose path does not pass over conductive areas and do not violate the designed spacing requirements may be uninsulated. Insulation, when required on the jumper wires, needs to be compatible with conformal coating.

11.2.1 Jumper Wires – Wire Selection

These criteria replace all of 11.2.1 in published IPC-A-610D.

The following considerations are to be made when selecting wires for jumpers:

1. Wire is insulated if greater than 25 mm [0.984 in] in length or is liable to short between lands or component leads.
2. Silver plated stranded wire should not be used. Under some conditions corrosion of the wire can occur.
3. Select the smallest diameter wire that will carry the required current needs.
4. The insulation of the wire should withstand soldering temperatures, have resistance to abrasion, and have a dielectric resistance equal to or better than the board insulation material.
5. Recommended wire is solid, insulated, plated copper wire.
6. Chemical solutions, pastes, and creams used to strip solid wires do not cause degradation to the wire.
7. A unique color shall be used for modification wires on PWB assemblies; this shall be different from the colors used during normal manufacturing.
11.2.2 Jumper Wires – Wire Routing

These criteria replace all of 11.2.2 in published IPC-A-610D.

Acceptable
- Unavoidable crossing of component footprint or land area.

Defect
- Insufficient slack in wire to allow relocation from unavoidable lands during component replacement.

11.2.3 Jumper Wires – Wire Staking

These criteria replace all of 11.2.3 in published IPC-A-610D.

Jumper wires on PCB assemblies shall be secured to the PWB using adhesive or tape (dots or strips); wires shall not be secured to components or component leads.

When adhesive is used, it is to be mixed and cured in accordance with the manufacturer’s instructions. All adhesive must be fully cured before acceptance.

Adhesives/tapes used to secure jumper wires to PCB assemblies shall maintain their adhesive properties for the design life of the equipment.

Spot bond so that the stake fillet is sufficient to secure the wire with no spillover onto adjacent lands or components.

Jumper wires are not to be staked to, or allowed to touch, any moving parts or sharp edges. Wires are staked within the radius of each bend for each change of direction.

11.2.4 Jumper Wires – Plated-Through Holes

These criteria replace all of 11.2.4 in published IPC-A-610D.

Jumper wires may be attached by any of the following methods. However, the method used for a particular assembly type needs to be defined.

This section is intended to show jumper wire practices that are used in original manufacturing and/or repair.

Jumper wires shall, where possible, be inserted into plated through-holes (component locations or PCB vias) and soldered into position. When practical, unused plated through-holes shall be used. Plated through-holes already containing components may be used if there is sufficient room for additional leads. The component lead and jumper wire shall exhibit protrusion in the soldered connection.

Where plated-through hole installation of modification wires on PCB assemblies is not possible, lap soldering of modification wires to surface mount vacant land lands, surface mount component pad/leads and PCB traces, can be performed if requirements contained herein are met.

11.2.4.1 Jumper Wires – PTH/Via – Lead in Hole

These criteria replace all of 11.2.3 in published IPC-A-610D.

Acceptable
- Wire soldered into PTH with component lead.
Added criteria in this addendum.

All individual cables and cable harness assemblies shall contain the part number, revision level, date code (date of manufacturer), and supplier identification (name, abbreviation, or number).

Supplier lot control numbers/date codes shall be marked on cables and harnesses.

The component manufacturer’s recommended tooling and processes shall be used in all preparation and assembly operations. Splicing is not permitted.

**14 Modification and Repair**

Added criteria in this addendum.

**Modifications:**
Modifications are defined as the alteration of printed circuit boards (PCBs) to incorporate approved engineering changes. Modified PCBs shall be clearly identified (e.g., raising revision level or variant) to avoid confusion with unmodified product. Before beginning any modifications, engineering shall provide documented & released process instructions.

**Repairs:**
Conductor short repairs (cut/drilled traces, etc.) shall be limited to a maximum of six per PWB, provided a qualified polymeric coating is subsequently applied to the affected area. Repairs to outer layer conductors of PWBs for open circuits (added wires, welded conductors, etc.), shall not exceed five for a single cause (such as a single scratch through up to five adjacent conductors); however, the limit is one, solitary defect per 0.064 square meters [100 square in]. For boards of less than 0.064 square meters [100 square in], five repairs for a single defect cause are permitted.

**SUBTRACTIVE MODIFICATIONS/REPAIRS**

**Cut Traces:**
- The width of all circuit trace cuts shall exceed 0.063 mm [0.005 in].
- All loose material shall be removed from the cut area.
- Circuit trace cuts shall be sealed with an approved epoxy.
- Removed circuit traces must be a minimum of 0.063 mm [0.005 in] from lands, circuit junctions, and component leads.

**Holes and Terminals:**
Holes may be drilled in boards to add terminals, to route added wires, or to interrupt internal circuits providing the following conditions are met:
- The drilled hole does not interfere with other circuits.
- There is no smeared metallization that could short ground and power planes on multi-layer boards.
- Holes to interrupt internal circuits and holes penetrating more than one conductive layer must be filled with epoxy to prevent absorption of moisture or other contaminants.
- The edge of the drilled hole shall be a minimum of 0.38 mm [0.015 in] away from any adjacent hole, pad, internal PTH (Plated Through-Hole) clearance diameter, etc.
- Excess, mislocated or unused holes or slots in boards may be filled with an approved epoxy.

**Lifted/Cut Component Leads:**
- Lifted (truncated) pins shall be cut short enough to prevent shorting to the pad from which they were lifted.
- Minimum electrical clearance requirements shall be maintained.
COMPONENT ADDITIONS

Labeled Components

- Connections must be supported, preferably by existing terminals or PTH. Terminals may be added as the case dictates.
- Added components shall be soldered into plated through-holes (component locations or PCB vias). Added components shall be mounted on the same side of the PCB as the original mounted component.
- Butt mounting of axial leaded components is prohibited.
- Components not reasonably secure shall have epoxy applied between the body and PCB surface.

SMT Components

Surface mounted components shall be added only where lands are provided. The use of additional adapter board supported SMT lands is permitted to replace damaged lands or to incorporate approved engineering changes. SMT pad size and configuration shall be as specified for the component.

CONDUCTOR REPAIR

General Requirements

The following repair methods may be used to repair conductor breaks, scratches, or similar defects; see Section 11.2 conductor repair.

Lifted or debonded circuit traces may be replaced with lap-soldered jumper wires. PTHs, lands, and vias shall be used wherever possible. Wires may be lap-soldered to circuit traces if PTHs, lands, or vias are not available.

Jumper wire size, spacing, and current carrying capacity must not be reduced below allowable tolerance or electrical requirements. Jumper wire size shall not exceed the width of the defective circuit trace.

15 Finished Surfaces

Added criteria in this addendum.

The following classifications are to be used for inspection of finished surfaces unless workmanship requirements are specified on the released engineering drawing.

Note: The terms Grade 1, Grade 2 and Grade 3 correspond to terms commonly used in the Telecom industry Class 1, Class 2 and Class 3 where Grade 1/Class 1 are the most stringent requirements. In IPC documents the terms Class 1, 2, or 3 are used to reflect criticality of need and ability to operate in harsh environmental conditions (thermal, vibration, etc.) where Class 3 are the most stringent requirements. In this addendum the committee chose to use the designation “Grade” instead of “Class” to reduce confusion with the Class designations used in all IPC documents.

Grade 1 Surfaces

- Surfaces frequently viewed in the finished product by the final customer (Examples: Front covers, module covers, faceplates, filler panels, heat ramps, external labels, etc.).
- Grade 1 surfaces shall be free of blisters, clamp or brake marks, extrusion lines, gouges, nicks, pits, runs, scratches, extraneous or irregular sanding lines, spot-weld craters, voids, or other defects which detract from the general appearance.
- Appearance of a grade 1 surface is as important as form, fit, and function.

Grade 2 Surfaces

- Surfaces occasionally viewed in the finished product by the final customer (Examples: Internal labels and surrounding area, inside of accessible covers, side panels visible from the front, outside of rear covers, outdoor equipment enclosures, etc.).
- Grade 2 surfaces may have slight surface imperfections/scratches if they are not readily noticeable from a distance of 18 inches.
- Appearance of a grade 2 surface, while important, is secondary to form, fit, and function.
- Consideration should be given to how the flaw affects the general appearance.
Grade 3 Surfaces
- Surfaces infrequently or never viewed in the finished product by the final customer (Examples: Normally concealed surfaces, bottom plates, top plates, internal surfaces of assemblies, etc.).
- Grade 3 surfaces are allowed to have a limited number of minor flaws that would be considered non-conforming in Grade 1 and 2 as long as form, fit, and function of the part are not affected.
- Scratches that are visible at a distance of 457 mm [18.0 in] are allowed providing the scratch does not expose the base material.
- Form, fit, and function are the primary considerations when evaluating a grade 3 surface.

Evaluation Requirements
When evaluating a flaw, consider whether the flaw adversely affects the general appearance, based on the quality requirements for the surface exposure classification.

The product shall be viewed under the following conditions:

<table>
<thead>
<tr>
<th>Angle</th>
<th>Product shall be viewed within the viewing range as shown below.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>Approximately 457 mm [18.0 in].</td>
</tr>
<tr>
<td>Lighting</td>
<td>Use normal room lighting for exterior surfaces; inspection lamps may be used for interior surfaces.</td>
</tr>
<tr>
<td>Magnification</td>
<td>None; increased magnification may be used for verification of functional flaws only.</td>
</tr>
<tr>
<td>Time</td>
<td>A sufficient amount of time should be used to inspect the product. When making an accept/reject judgment about a flaw, avoid using concentrated study.</td>
</tr>
</tbody>
</table>

The following is a suggested guideline (see Figure 15-1). View the area at an approximate rate of 5 seconds per square foot. Based on the quality requirements for the surface, consider whether the flaw adversely affects the general appearance.

Figure 15-1
A. Viewing range
B. Viewing surface
15.1 General Finish Requirements and Acceptance Criteria

Added criteria in this addendum.

Target

• Cosmetic and protective finishes shall be of uniform appearance and typically smooth; deliberately textured finishes are permissible when directed by engineering documentation.

• Finishes shall conform to environmental conditions and restrictions as delineated in engineering documentation. Finishes shall also be resistant to cleaning agents or other manufacturing processes and shall not functionally degrade over the expected life of the product.

• All finishes, regardless of class, shall provide the intended corrosion protection. Exposed base material is a defect in any finish class.

• Touch-up of finishes on all grades is allowed. Completed touch-up areas shall meet the requirements of the appropriate finish grade.

Acceptable

• See specific finish sections for detailed criteria on acceptable finishes.

Defect

• Flaws on mechanical assembly component parts, that may in any way endanger the safety of persons using or coming in contact with these parts, are always considered defects.

• Flaws that affect the form, fit, or function of a part or the product, regardless of surface exposure classification, are always considered defects.

• There shall be no evidence of bleed-out or corrosion due to entrapment of plating or cleaning solutions.

• See specific finish sections for detailed criteria on defect finishes.
15.2 Adhesion Requirements for Chromated Surfaces

Added criteria in this addendum.

Adhesion Tape Test

- Adhesion of chromated surfaces **shall** be determined by the following adhesion tape test. A new strip of tape **shall** be used for each test.
- A two inch minimum effective length of pressure sensitive tape conforming to the requirements of Federal Specification PPP-T-42C, Type II (such as 3M Flatback Tape #250™) **shall** be firmly pressed onto the surface to be tested.
- All air bubbles should be rubbed out.
- Allow approximately 10 seconds for the test area to return to room temperature.
- Grasp a free end of the tape and at a rapid speed, strip it by pulling the tape back on itself at 90-180° so that the tape is folded back to back during the procedure.

**Acceptable**
- No presence of chromate coating on the removed tape.

**Defect**
- Any chromate coating present on the removed tape.

15.3 Adhesion Requirements for Silkscreen Ink

Adhesion Tape Test

- Ink **shall** have sufficient adhesion to withstand the following adhesion tape test. A new strip of tape **shall** be used for each test.
- Flatback™ masking tape conforming to the requirements of Federal Specification PPP-T-42C, Type II (Minnesota Mining and Manufacturing Company, No. 250) and of sufficient width to cover the characters **shall** be used.
- Press a strip of the tape approximately 50.8 mm [2 in] long firmly across the silkscreen ink surface and substrate.
- Immediately remove a short length of one end of the applied tape and then rapidly remove the tape by manual force applied 90-180° to the ink marking.

**Target**

**Acceptable**
- No presence of ink on the removed tape.

**Defect**
- Any portion of ink markings present on the removed tape.

15.4 General Requirements for All Surfaces

Added criteria in this addendum.

Requirements for physical defects and finish defects are in Tables 15-1 and 15-2.
# Physical Defects

The following defects refer to physical defects (disturbing base material, mechanical damage, etc.).

**Note:** the headers Grade 1, Grade 2 and Grade 3 correspond to terms commonly used in the Telecom industry Class 1, Class 2 and Class 3 where Grade 1/Class 1 are the most stringent requirements. In this addendum the committee chose to use the designation “Grade” instead of “Class” to reduce confusion with the Class designations used in all IPC documents.

In IPC documents the terms Class 1, 2, or 3 are used to reflect criticality of need and ability to operate in harsh environmental conditions (thermal, vibration, etc.) where Class 3 are the most stringent requirements.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burrs</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable providing it is permanently attached and does not cause a safety hazard, nor interfere with or chafe on any other equipment.</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
</tr>
<tr>
<td>Dent</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Unacceptable if dent affects function or alignment.</td>
</tr>
<tr>
<td>Die, Tool, or Brake Mark</td>
<td>Unacceptable</td>
<td>Acceptable, providing they are consistent in appearance, do not exceed 0.076 mm [0.003 in] in depth, and high areas are sanded flush with surrounding surfaces.</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Flat Head Rivet</td>
<td>Unacceptable</td>
<td>Acceptable providing it is flush to .005 inches below the surrounding surfaces.</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Fracture</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
</tr>
<tr>
<td>Material Pitting</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable if less than 1.59 mm [0.0625 in] in diameter.</td>
</tr>
<tr>
<td>Mechanical Misalignment</td>
<td>Unacceptable</td>
<td>Acceptable, providing parts can be adjusted to achieve a balanced appearance.</td>
<td>Acceptable, providing functionality of equipment is not affected.</td>
</tr>
<tr>
<td>Mold Line</td>
<td>A visible line is acceptable.</td>
<td>A visible line is acceptable.</td>
<td>A visible line is acceptable.</td>
</tr>
<tr>
<td>Flash</td>
<td>Unacceptable</td>
<td>Permanently attached flash <strong>shall not</strong> exceed the appropriate dimensional tolerance of the part. Flash that can be easily removed <strong>shall</strong> be removed.</td>
<td>Permanently attached flash <strong>shall not</strong> impair the functionality of the equipment. Flash that can be easily removed <strong>shall</strong> be removed.</td>
</tr>
<tr>
<td>Spot-Weld Crater</td>
<td>Unacceptable</td>
<td>Acceptable providing it is flush to .13 mm [.005 in] below the surrounding surfaces.</td>
<td>Acceptable</td>
</tr>
<tr>
<td>Weld Burn</td>
<td>Unacceptable</td>
<td>Yellow to brown discoloration is acceptable (except aluminum). Purple discoloration on stainless steel is unacceptable.</td>
<td>Yellow to brown discoloration is acceptable (except aluminum). Purple discoloration on stainless steel is unacceptable.</td>
</tr>
<tr>
<td>Weld Flash and Splatter</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable providing it is permanently attached, does not cause a safety hazard, nor interfere with or chafe on any other equipment. Flash that can be easily removed <strong>shall</strong> be removed.</td>
</tr>
</tbody>
</table>
## 15.4 General Requirements for All Surfaces (cont.)

### Table 15-2 Criteria for Enclosures and Other Finished Surfaces - Finish Defects

<table>
<thead>
<tr>
<th>Finish Defects</th>
<th>Unacceptable</th>
<th>Unacceptable</th>
<th>Unacceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Adhesion</strong> - (Loss of, e.g., peeling)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Bleeding</strong> (e.g., between painted surfaces)</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Gradual color change is acceptable.</td>
</tr>
<tr>
<td><strong>Blistered Finish</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Unacceptable if greater than 3.2 mm [0.125 in] in length or corrosion susceptible material is exposed.</td>
</tr>
<tr>
<td><strong>Crack or Chip in Finish</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Unacceptable if greater than 3.2 mm [0.125 in] in length or corrosion susceptible material is exposed.</td>
</tr>
<tr>
<td><strong>Discoloration or Non-uniform Texture</strong></td>
<td>Unacceptable</td>
<td>Gradual discoloration or texture change is acceptable.</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Entrapped Foreign Material</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Orange Peel</strong></td>
<td>Unacceptable</td>
<td>Acceptable</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Overspray</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Pinhole</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Unacceptable if corrosion susceptible material is exposed.</td>
</tr>
<tr>
<td><strong>Pitting or Plating Etching</strong></td>
<td>Unacceptable</td>
<td>Acceptable if localized in an area less than 50.8 mm [2.0 in] in diameter.</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Plating Bleedout</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Unacceptable</td>
</tr>
<tr>
<td><strong>Plating Burn</strong></td>
<td>Unacceptable unless specifically allowed by applicable plating specification.</td>
<td>Unacceptable unless specifically allowed by applicable plating specification.</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Plating Stain or Burnish</strong></td>
<td>Unacceptable</td>
<td>Refer to applicable plating specifications.</td>
<td>Refer to applicable plating specifications.</td>
</tr>
<tr>
<td><strong>Run</strong></td>
<td>Unacceptable</td>
<td>A run is acceptable if it does not exceed 6.4 mm [0.25 in] wide by 50.8 mm [2.0 in] long and there is no more than 1 run per 0.0036 square m [1.0 square ft].</td>
<td>Acceptable</td>
</tr>
<tr>
<td><strong>Sag</strong></td>
<td>Unacceptable</td>
<td>A slight sag is acceptable if it is no greater than 50.8 mm [2.0 in] wide and there is no more than 1 sag per 0.0036 square m [1.0 square ft].</td>
<td>More than 2 sags per 0.0036 square m [1.0 square ft] is unacceptable.</td>
</tr>
<tr>
<td><strong>Scratch</strong></td>
<td>Unacceptable</td>
<td>Slight scratches (e.g., sanding and polishing marks) are acceptable, providing that the scratches cannot be felt with a finger and not readily noticeable at a distance of 457 mm [18.0 in].</td>
<td>Scratches are acceptable, providing that no corrosion susceptible material is exposed.</td>
</tr>
<tr>
<td><strong>Smear</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable providing that corrosion susceptible material is not exposed.</td>
</tr>
<tr>
<td><strong>Thin Spot</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable providing that corrosion susceptible material is not exposed.</td>
</tr>
<tr>
<td><strong>Void</strong></td>
<td>Unacceptable</td>
<td>Unacceptable</td>
<td>Acceptable providing that corrosion susceptible material is not exposed.</td>
</tr>
</tbody>
</table>
Added criteria in this addendum.

Rivets **shall** be installed with well-formed driven heads seated tightly against their bearing surface (any evidence of loose parts or loose rivets that can be moved or turned with finger tip pressure **shall not** be acceptable). Joined parts **shall** fit firmly showing no significant distortion or other physical damage (such as tool marks as a result of the riveting operation). There **shall** be no foreign material captured between the mating materials or under the heads of the rivet.

Hollow shank rivets, such as tubular rivets, **shall** be installed tight against their mounting surface with no portion of the hole visible. The driven head **shall** be formed with a rollover line having complete contact with the mounting surface. The internal portion of tubular rivets **shall** be free of any visible cracks or distortion.

Pop rivets **shall** meet all of the criteria for tubular rivets except that the rollover on the backside of the rivet is not present.

**Target**

- Rivets used to install handles must not exceed a height of 0.38 mm [0.015 in] as measured from the handle surface to the top of the rivet and cannot exceed the allowable maximum or minimum component height for that assembly (refer to Section 4.5).
- Internal gap equal to or less than 0.15 mm [0.006 in] (A) and gap does not extend to rivet shank (B).
- The heads of flat countersunk head rivets **shall** be between 0.64 mm [0.025 in] above flush and 0.13 mm [0.005 in] below flush. The heads **shall not** protrude to the extent that mechanical interference will result.
- Mating surfaces free of foreign material or burrs (C).
- Slight gap under rivet head where 50% of the head is in contact with the mating surface and the gap does not exceed 0.38 mm [0.015 in].
- Cut or tool mark in material less than 25% of the material thickness (A) or cut in rivet head less than 0.64 mm [0.025 in] (B).
15.5 Rivets (cont.)

Defect
- Internal gap between joined materials exceeds 0.15 mm [0.006 in] (A).
- Gap extends to rivet shank (B).
- Burrs, foreign material between mating surfaces (C).
- Rivet swelled between joined materials (B).
- Rivet is not seated firmly.
- Joined material visibly distorted (A) or tool marks evident (B).
- Cut or tool mark in material surface more than 25% of material thickness or 0.38 mm [0.015 in] deep (A), whichever is less.
- Cut in rivet head more than 0.25 mm [0.010 in] deep (B).
Added criteria in this addendum.

Acceptable

- Bevel driven head: The formed head **shall** be between 25-75% of the original head height.
- Offset driven head: The head can be off center with the shank but the shank **shall not** be exposed.
- Step driven head: The minimum thickness **shall** be 25% of the original head height.

Figure 15-11

Figure 15-12

Figure 15-13
Added criteria in this addendum.

Acceptable

- Rivet tight against mounting surface.
- Rollover complete.
- Edge of hole not visible.
- Gap equal to or less than 0.051 mm [0.002 in].
- Splits in the head of the rivet are acceptable providing there are no more than 3, all spaced greater than 90° apart, and they do not extend into the rivet shank.
- Pop rivets do not need to have a captive mandrel present as long as the secondary head is fully formed.

Defect

- Rivet not tight against mounting surface.
- Rollover incomplete.
- Edge of hole visible.
- Gap greater than 0.051 mm [0.002 in].
- More than 3 splits in the head of the rivet or excessive bulges that may weaken the rivet.
- Secondary head on pop rivet is not fully formed and rivet is loose.
- Rivet too short and does not form proper rollover (A).
- Driven head flattened, formed with improper tool (B).
- Insufficient forming, bulged ends not curled (C).

Figure 15-14

Figure 15-15

Figure 15-16
General Requirements

Optical connectors are used to connect, disconnect, and reconnect fiber cables with a minimum of signal loss. Small cracks on the face of an optical connector reduce signal power; large cracks cause signal loss. An optical connection is made by physically aligning two optical fibers so that both fibers illuminate and touch one another. As a result, contamination of these surfaces caused by dust, oil from operator’s fingers, or other foreign matter may cause excessive signal loss or connector damage. Therefore, operators and technicians shall inspect and, if needed, clean all fiber end connectors before any assembly or testing is performed.

The following requirements should also be observed:

- Never bend or coil cable less than the minimum bend radius (Refer to Section 13.4).
- Dry nitrogen (only) shall be used to blow loose contaminants from optical fiber connectors.
- If a wet process is used to clean fiber optics (example Isopropyl Alcohol) it must be followed up with a dry cleaning process and visual inspection.
- Canned compressed air shall not be used.
- Do not pull on fiber cables or allow them to support any weight.
- When handling fiber assemblies, always handle by the connectors.
- Never touch the fiber cable ends or module connectors.
- Avoid twisting fiber cable while turning end connectors or routing the cable during installation and test.
- Do not allow optical connectors to strike or drag across work surfaces or the floor.
- Do not allow fiber cable ends/module connectors to be uncapped when not in use.
- Cable ties shall not be used to secure fiber optic cables.

General Inspection Requirements

The elements of fiber optic cable and connector end face are illustrated in Figures 16-1 and 16-2.

- Fiber optic connectors are normally inspected at 200X magnification with up to 400X used for defect resolution.
- Use a video feed optical viewing scope (min. 200X magnification) if powered optics must be inspected.
- The core of the fiber should be readily visible if the opposite end of the fiber is illuminated.

Warning

Never look into the end of an optical fiber while optical power is being applied to the fiber.

When cleaning or making measurements, avoid eye exposure to open-ended fibers and optical connectors because they may be connected to laser transmitters.
Figure 16-1
Main Elements of Fiber Optic Cable:
A. Outer jacket
B. Strength members
C. Buffer jacket
D. Optical fiber
D1. Silicone coating
D2. Cladding (silica)
D3. Core (silica)

Figure 16-2
Main elements of Connector End
A. Fiber core
B. Fiber cladding
C. Ferrule
D. Epoxy
16.1 Bend Radius Requirements – Fiber Optic Cabling

Added criteria in this addendum.

Unless otherwise specified by design, fiber manufacturer, or the OEM, the Table 16-1 and Figure 16-3 should be used to determine the minimum allowable bend radius.

Table 16-1 Cable Bend Radius

<table>
<thead>
<tr>
<th>Cable Type</th>
<th>Minimum Bend Radius (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffered &amp; Jacketed Single Fibers</td>
<td>1 in.</td>
</tr>
<tr>
<td>Larger Jacketed Fibers</td>
<td>15X Fiber Cable Diameter</td>
</tr>
</tbody>
</table>

Caution must be observed when handling or assembling optical glass cable. Violating the minimum bend radius can cause the following effects:

- Bends increase attenuation. Bends change the angles of reflection enough to affect transmit or receive power (see Figure 16-4).
- Bends may cause micro fractures along the surface of the fiber. Micro fractures will eventually cause a break in the fiber causing signal loss.
- Micro bends are small variations or “bumps” in the core to cladding interface (see Figure 16-5). Micro bends can cause high-order modes to reflect at angles that will not allow desired reflection (the light signal may be reduced or lost).
16.1 Connector End Face

Added criteria in this addendum.

Fiber Optic end faces shall be inspected at 200x magnification for surface anomalies.

16.1.1 Connector End Face – Non-angled PC Polish Connectors

Added criteria in this addendum.

Acceptability of non-angled PC polish connectors shall conform to Table 16.2.

Table 16-2 Allowable Defects for Non-angled PC Polish Connectors

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
<th>Diameter</th>
<th>Allowable Defects/Scratches</th>
<th>Contamination/Pits (non-removable)</th>
<th>Scratches</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Core Zone</td>
<td>0 to 25 µm</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>(Single-Mode)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Core Zone</td>
<td>0 to 66 µm</td>
<td>5 &lt;5 µm</td>
<td>5 µm</td>
<td>none &lt;3 µm</td>
</tr>
<tr>
<td></td>
<td>(Multi-Mode)</td>
<td></td>
<td>none</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>Cladding Zone</td>
<td>25 - 120 µm</td>
<td>Any &lt;2 µm</td>
<td>none &gt;3 µm</td>
<td>none &gt;3 µm</td>
</tr>
<tr>
<td></td>
<td>(Single-Mode)</td>
<td></td>
<td>5 from 2 -5 µm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cladding Zone</td>
<td>66 - 130 µm</td>
<td>Any &lt;2 µm</td>
<td>none</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Multi-Mode)</td>
<td></td>
<td>8 from 2 -5 µm</td>
<td>none &gt;3 µm</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Adhesive Zone</td>
<td>120 - 130 µm</td>
<td>any</td>
<td>any</td>
<td>any</td>
</tr>
<tr>
<td>D</td>
<td>Contact Zone</td>
<td>130 - 250 µm</td>
<td>None &gt;10 µm</td>
<td>any</td>
<td>any</td>
</tr>
</tbody>
</table>

Table Notes:
1) When inspecting after polishing or while performing quality assurance of a new connector, a limit of five fine scratches (<3 µm) may be set in Zone B in order to establish that a reliable process is being used by the manufacturer.
2) Any contaminants that are removable must be cleaned from the end-face.
3) Any defects or scratches that extend across multiple zones are subject to the most stringent criteria.
4) The size of a defect is equal to the smallest circle that can completely encompass the defect.
5) Defects are defined as "permanent nonlinear features." This includes contamination, pits, etc.
6) Scratches are defined as "permanent linear features."
7) MT ferrules (e.g., ribbon) have allowable edge chipping from 115 to 125 µm.
8) Zone D criteria does not apply to MT-ferrule or Metallic-ferrule connectors.
9) Cracks, that when extended intersect Zone A, are not allowed.
Added criteria in this addendum.

Acceptability of receptacles (with internal fiber stubs) shall conform to Table 16-3.

### Table 16-3  Allowable Defects for Receptacles (with internal fiber stubs)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Description</th>
<th>Diameter</th>
<th>Allowable Defects/Scratches&lt;sup&gt;2, 3&lt;/sup&gt;</th>
<th>Contamination/Pits (non-removable)&lt;sup&gt;4, 5&lt;/sup&gt;</th>
<th>Scratches&lt;sup&gt;6&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Core Zone (Single-Mode)</td>
<td>0 to 25 µm</td>
<td>None</td>
<td>5 &lt;5 µm</td>
<td>5 &lt;3 µm</td>
</tr>
<tr>
<td></td>
<td>Core Zone (Multi-Mode)</td>
<td>0 to 66 µm</td>
<td>5 &lt;5 µm none &gt;5 µm</td>
<td>5 &lt;3 µm none &gt;3 µm</td>
<td></td>
</tr>
<tr>
<td>B&lt;sup&gt;7, 9&lt;/sup&gt;</td>
<td>Cladding Zone (Single-Mode)</td>
<td>25 - 120 µm</td>
<td>Any &lt;5 µm 5 from 5 -10 µm none &gt;10 µm</td>
<td>none &gt;3 µm&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cladding Zone (Multi-Mode)</td>
<td>66 -130 µm</td>
<td>Any &lt;5 µm 8 from 5 -10 µm none &gt;10 µm</td>
<td>none &gt;3 µm&lt;sup&gt;1&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Adhesive Zone</td>
<td>120 - 130 µm</td>
<td>any</td>
<td>any</td>
<td></td>
</tr>
<tr>
<td>D&lt;sup&gt;7, 8&lt;/sup&gt;</td>
<td>Contact Zone</td>
<td>130 - 250 µm</td>
<td>any &lt;20 µm 3 from 20 - 50 µm None &gt;50 µm</td>
<td>any</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:**
1) When inspecting after polishing or while performing quality assurance of a new connector, a limit of five fine scratches (<3 µm) may be set in Zone B in order to establish that a reliable process is being used by the manufacturer.
2) Any contaminants that are removable must be cleaned from the end-face.
3) Any defects or scratches that extend across multiple zones are subject to the most stringent criteria.
4) The size of a defect is equal to the smallest circle that can completely encompass the defect.
5) Defects are defined as “permanent nonlinear features.” This includes contamination, pits, etc.
6) Scratches are defined as “permanent linear features.”
7) MT ferrules (e.g., ribbon) have allowable edge chipping from 115 to 125 µm.
8) Zone D criteria does not apply to MT-ferrule or Metallic-ferrule connectors.
9) Cracks, that when extended intersect Zone A, are not allowed.

**Target**
- No evidence of contamination, scratches, or any other anomaly.
Acceptable

- Contamination falls within Cladding Zone but outside of Core Zone. Diameter is less than 2 µm.
- Contamination is in Contact Zone and diameter is less than 10 µm.
- Contamination (less than 2 µm) in Cladding / Epoxy Zone.
- One scratch (less than 3 µm) in Cladding Zone. Multiple scratches in Contact Zone.
Defect
  • Heavy cracks and chips.
  • Core area damaged.

Defect
  • Fiber surface pulverized by rotational contact with mating connector. ("Crashed")

Defect
  • Severe chipping and cracking. ("Crashed")
Defect

• Large chip or surface pitting.

Defect

• Scratches across face of fiber, typical of coarse polish. Core not visible.

Defect

• Surface cracks and chips extending into core area. Core area damaged.
16.1.2 Connector End Face – Receptacles (with internal fiber stubs) (cont.)

Defect
- Contamination in the Core Zone.

Defect
- Large Particle in Cladding Zone.

Defect
- Scratch through Core.
16.1.2 Connector End Face – Receptacles (with internal fiber stubs) (cont.)

Defect
- Particle in Cladding Zone exceeds maximum allowed diameter.

Defect
- Removable (Oil) Contamination - must be cleaned and re-inspected.

Defect
- Large contamination on core/cladding. (Multi-cable example.)
16.1.3 Acceptance Criteria for Receptacles (with lens)

Added criteria in this addendum.

A lensed device consists of a ball lens located inside the barrel of an optical device. One will not be able to identify a clearly defined core and cladding area.

**Defect**
- Deep surface crack near core area.

![Figure 16-23](image1)

**Defect**
- Deep surface crack near core area.

![Figure 16-23](image2)
Defect
- Severe chipping. ("Crashed")

Defect
- Foreign material on surface and contaminated.

Note: The connector end face shall not have particles or residues of any kind on its surface at the time of connection.

Defect
- Deep scratch in core area.
It may be possible to identify a lensed device visually without the inspection tool. Figure 16-30 shows a transceiver with a combined fiber stub and lens. The fiber stub is in the port on the left. The lensed device is the port on the right.
16.1.4 Lensed Device Acceptance Criteria

Added criteria in this addendum.

The lensed device is to be inspected for contamination, damage, or defects in the glass per the inspection criteria in the below table. The main area of concern is the 500 µm viewing area (A). This will be almost the entire area that is visible at 200X magnification. The Outer diameter of the lens (i.e., the 1.5 mm Region C) will not be visible at this magnification. For this area, a lower magnification should be used.

<table>
<thead>
<tr>
<th>Area</th>
<th>Diameter</th>
<th>Particles</th>
<th>Bubbles in Glass</th>
<th>Cracks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region A</td>
<td>500 µm</td>
<td>Max. Qty. 3</td>
<td>None &gt;75 µm</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max. Dia. 75 µm</td>
<td>Max Qty 3 Dia. 25-50 µm</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>No Limit Dia. &lt;25 µm</td>
<td></td>
</tr>
<tr>
<td>Region C</td>
<td>1.5 mm</td>
<td>No Limit</td>
<td>No Limit Dia. &lt;125 µm</td>
<td>None</td>
</tr>
</tbody>
</table>
Added criteria in this addendum.

Target
- No damage to jacket.

Acceptable
- Slight discoloration/melting are acceptable if caused by incidental contact with soldering iron during assembly or rework.
- Damage shall not expose fiber.

Defect
- Melted jacket with visibly burned (charred) area.
- Discoloration/melting related to power/heat sources contained within the effected assembly.
- Any cut or burn that exposes inner layers.
- Jacket with compression marks evident.
- Possible crushed fiberglass core.
The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard. Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

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1. I recommend changes to the following:
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   __ Test Method number ______, paragraph number ______

   The referenced paragraph number has proven to be:
   __ Unclear  __ Too Rigid  __ In Error
   __ Other

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