PRINTED WIRING PRODUCTS
RESIN-COATED METAL TYPE
GENERAL EQUIPMENT REQUIREMENTS

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1. GENERAL

A. Scope

1.01 This section specifies general engineering requirements for resin-coated metal printed wiring products. Part 1 contains general information, Part 2 contains design recommendations, Part 3 covers requirements for printed wiring boards, Part 4 covers requirements for printed wiring assemblies, and Part 5 contains definitions.

1.02 The requirements covered in this section shall be followed for all resin-coated metal-type printed wiring products, except as modified by drawings and specifications for individual designs.

B. References

1.03 Requirements for rigid etched-foil type printed wiring products are covered in Section 800-610-159.

1.04 Requirements for flexible etched-foil type printed wiring products are covered in X-17410 (manufacturing requirements) and in X-17442 (assemblies).

2. DESIGN RECOMMENDATIONS AND CONSIDERATIONS

2.01 ***General:*** This part does not cover engineering requirements, but contains generalized recommendations for use by design engineers as an aid toward designing products that can meet the engineering requirements covered in subsequent parts. See Design Standards, Book 1 and A-312600 for more detailed discussion of design considerations.

2.02 ***Datum Points:*** Datum points should be provided to establish the location of datum lines, from which all features are located.

2.03 ***Modules:*** The requirements covered in subsequent parts of this section are based

upon modular grid layouts which define the position of the conductor pattern and holes. The smallest module used is 0.025 inch.

2.04 ***Component Mounting:*** Where space permits, large rectangular wire-leaded components such as the 535- and 542-type capacitors should be mounted flat (with largest area of component against the board). When this is not possible, the component may be mounted edgewise (with rounded surface against the board). Since this type of mounting may bring about the breakage of leads due to handling, vibration, shock, etc, additional support may be provided as required. Mounting the component close to other components to limit movement, grouping and tying similar components together, and providing a bracket are methods that have been used for providing additional support.

2.05 ***Component Orientation:*** Where components of different sizes are used, similar units should be placed in even rows or groups over the surface of the board where circuit design permits. Where possible, component apparatus should be oriented either parallel or perpendicular to the long dimension of the board. Relays should be oriented so as to minimize the possibility of contact contamination. Component arrays having a directional intermix should be avoided. Where possible, polarized components should be mounted in the same direction. When parts are placed side by side, space should be provided for maximum dimensions of the components. The distance between holes, when established for given sizes of components, should be maintained as a standard dimension across the printed wiring board and all codes of boards within that system.

2.06 ***Board Thickness:*** Resin-coated metal boards of 0.062 inch nominal thickness are standard. However, boards of other thicknesses can be manufactured at a cost penalty.

2.07 ***Conductor Pattern Material:*** One ounce (0.0014 inch thick) copper is preferred for resin-coated metal boards because of its compatibility with the fabrication process. Other thicknesses may be obtained when necessary, but at a cost penalty.

2.08 ***Terminal Areas:*** Terminal areas used for connection to a wire or terminal of a component should have an annular ring at least 0.035 inch wide around the component mounting hole. This recommendation is based upon present manufacturing tolerances, and is a compromise between space and cost considerations.

2.09 ***Peripheral Clearance:*** The distance between the edge of the board and the edge of a hole or a part of the conductor pattern should be at least 0.100 inch, with 0.150 inch preferred.

2.10 ***Base Material:*** The metal portion of the base may be made from either cold-rolled steel or aluminum alloy, with steel preferred. A-312600, Stage 1, covers fabrication of the metal blank.

2.11 ***Test Strips:*** It is desirable to provide dedicated areas on the board to be used for performance of peel strength tests of 3.10 and for checking solderability per 3.15.

3. REQUIREMENTS FOR RESIN-COATED METAL-TYPE PRINTED WIRING BOARDS

A. General

3.01 ***Materials:*** The materials employed in the fabrication of resin-coated metal printed wiring boards shall be as specified in the individual drawings and specifications.

3.02 ***Connector Fingers:*** Printed connector fingers, when specified, shall meet the requirements of X-17199.

3.03 ***Plated-Through Holes:*** Plated-through holes, when specified, shall meet the requirements of X-17428.

B. Dimensional Requirements

3.04 ***Flatness:*** Printed wiring boards shall be flat within the tolerances shown in Table A.

TABLE A

LONGER DIMENSION OF BOARD (INCHES)	DEVIATION (INCH)
0 through 4	0.015
Over 4 through 10	0.025
Over 10	0.100

3.05 ***Conductor Thickness:*** The tolerance for conductor thickness shall be +100 percent −0 percent when measured per ASTM D374, Method A.

3.06 ***Conductor Pattern Width:*** The tolerance for conductor pattern width (exclusive of contact fingers) shall be as specified in Table B. Defects per 3.14 shall not be considered when determining path width.

TABLE B

NOMINAL WIDTH (INCH)	LIMITS
0.030 and wider	+Unrestricted — 0.015
Less than 0.030	0.015 minimum

3.07 ***Spacing:*** Spacing not otherwise specified shall be as specified in Table C.

3.08 ***Terminal Areas:*** Terminal areas shall lie so that a minimum of 270 degrees of copper surrounds the hole. However, the junction between the terminal area and the connecting conductor path shall not be affected.

3.09 ***Front-to-Back Registration:*** Registration of conductor patterns on the component and noncomponent sides of double-sided boards shall be accurate enough to permit meeting all dimensional requirements of this section.

C. Mechanical Requirements

3.10 ***Peel Strength:*** The average minimum peel strength of the copper on the board shall be at least 5.0 pounds per inch, with no single value falling below 4.0 pounds per inch. Testing shall be per Manufacturing Standard 17000, Section 1041, after conditioning per ASTM D618, Procedure A.

3.11 ***Anomalies:*** Blisters, delamination, and extraneous areas of copper (to include residual copper deposits on board edges caused by photoprinting) are permissible provided that:

(a) Minimum spacing requirements of 3.07 are not violated.

(b) Blisters or delaminations do not extend under the conductor pattern.

(c) Peel strength requirements of 3.10 are met.

(d) Extraneous copper areas do not appear on the board edge adjacent or parallel to contact fingers.

3.12 ***Scratches:*** Scratches are permitted in the resin coating provided that they do not extend through to the base metal. Scratches are

TABLE C

BETWEEN	DIMENSION (INCH)	
	NOMINAL SPACING 0.030 AND GREATER	NOMINAL SPACING LESS THAN 0.030
Any two adjacent electrically-isolated portions of the conductor pattern, or between the conductor pattern and any other conductor	+Unrestricted −0.015	0.015 minimum
A component lead mounting hole on a double-sided board and any conductor other than its associated terminal area (see Fig. 1)	0.030 minimum	0.020 minimum

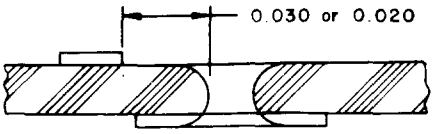


Fig. 1—Spacing Requirement on Double-Sided Board

permitted in the copper (except on contact fingers) provided that they do not reduce the cross-sectional area of the conductor pattern to less than 80 percent of the minimum dimension, judged visually. Scratches are permitted in the solder resist coating, provided they do not extend through to the copper, except as allowed in 3.17.

3.13 ***Conductor Pattern Separation:*** The conductor pattern shall not be separated from the base at any point, judged visually.

3.14 ***Nicks and Pinholes:*** Nicks and pinholes are permitted in the conductor pattern, except where they reduce the width to less than 80 percent of the minimum dimension at any point. In no case shall the width be reduced to less than 0.015 inch.

3.15 ***Solderability:*** All portions of the conductor pattern to which soldered connections are to be made shall meet the requirements of Manufacturing Standard 17000, Section 1065, Procedure D.

D. Cleanliness

3.16 Finished boards shall meet the following requirements of Manufacturing Standard 17000:

(a) Section 1093; no evidence of corrosion products on the copper.

(b) Section 1103; no chlorides shall be present.

(c) Section 1105; pH between 6.5 and 7.5.

E. Solder Mask

3.17 All parts of the conductor pattern to which soldered connections will not be made shall be covered with green solder resist coating per Finish Specification WL-2333. No more than three voids or scratches which expose the underlying copper and which are each 0.25 inch maximum in the longest dimension are allowed in the solder resist coating.

F. Marking, Screening, and Stamping

3.18 ***Color:*** The color of the marking ink shall be in contrast to the background.

3.19 ***Size:*** Ink characters shall be per Finish Specification WL-2151. Characters of 0.125 inch are preferred.

3.20 ***Clearance:*** The clearance between any part of the conductor pattern not covered by a solder mask per 3.17 and the ink characters shall not be less than the minimum specified on the manufacturing drawing.

3.21 ***Restoration of Designations:*** Obliterated or missing characters, whether screened, stamped, or deposited, shall be replaced (when required) with rubber-stamped characters of approximately the same size and color. Any such restored designations shall meet the clearance requirements of 3.20.

4. REQUIREMENTS FOR PRINTED WIRING ASSEMBLIES

A. General

4.01 The requirements covered in Part 3 shall apply to the completed assembly except as modified below.

(a) A conductor path discontinuity is acceptable if repaired in accordance with 4.18.

(b) A lifted portion of a conductor path which exceeds 0.5 inch in length is not acceptable. When the lifted portion is 0.5 inch or less in length, it is acceptable if repaired in accordance with 4.19.

(c) A lifted terminal area is acceptable if repaired in accordance with 4.19.

B. Jumper Connections

4.02 Jumper connections, when required, shall be made in accordance with Fig. 2 using tinned solid copper wire, insulated as required.

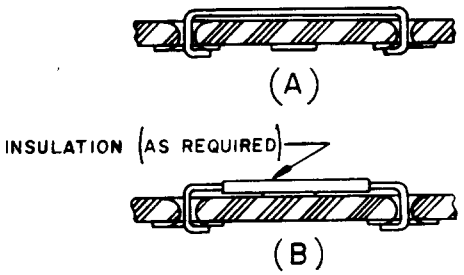


Fig. 2—Jumper Connections

C. Positioning of Components

4.03 ***Clearance:*** Clearance between adjacent conducting surfaces (including enameled wire) other than two parts of the conductor pattern shall be 0.030 minimum.

4.04 ***Component Marking Orientation:*** Code and electrical value markings on components need not all be oriented in the same direction. It is preferable, although not a requirement, for these markings to be visible.

D. Assembly of Components

4.05 ***Retention:*** Components shall be assembled in such a manner as to assure both satisfactory solder connections and the mechanical integrity of the final assembly. Clinched connections shall be used unless the design of the component incorporates an alternate fastening feature, or unless otherwise specified on individual drawings.

4.06 ***Damage to Components:*** Component leads shall not be fractured, nor shall the insulation (where furnished) be frayed. In order to avoid impairment of the seal in sealed components and to avoid breakage of leads, it is recommended that all component leads be as straight as practicable, without bends, for a distance of at least 0.063 inch from the body of the component. In the following cases, it is a requirement that the bend in a component lead shall not start closer than 0.063 inch from the point of attachment to the component.

(a) The lead emerges from a glass-sealed body.

(b) The lead is soldered or welded to any tubulation, such as in the case of 426-type diodes. No part of the tubulation extending from the glass end shall be bent or stressed.

(c) The lead is soldered or welded to the component leadout wire.

4.07 ***Clinched Connections***

(a) Clinched connections shall not reduce clearances between conductors to less than the minimum dimensions specified in 4.03 or on applicable manufacturing drawings.

(b) When round terminal areas are used, it is preferred that the leads be clinched in the direction of the conductor path.

(c) When elongated terminal areas are used, it is preferred that the leads be clinched in the direction of the long dimension of the terminal area.

4.08 ***Typical Assemblies:*** Fig. 3 through 7 illustrate assembly of typical components, and do not in themselves impose engineering requirements.

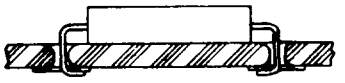


Fig. 3—Clinched Connection

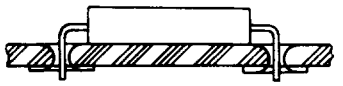


Fig. 4—Nonclinched Connection

E. Soldering

4.09 ***General:*** All soldering shall be in accordance with Manufacturing Process Specification 50016, Method D or L.

4.10 ***Soldering Anomalies***

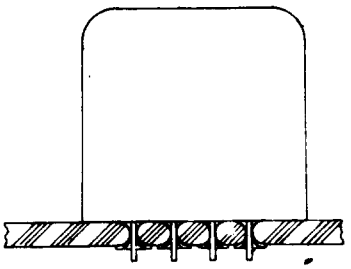


Fig. 5—Multiterminal Component

(a) Protruding wire ends and spines, bulges, and droplets of solder are acceptable, provided that:

(1) They are not likely to cause bridging if deformed.

(2) They are not hazardous to personnel.

(b) All solder joints shall be free from cracks. Surfaces of solder joints shall not show

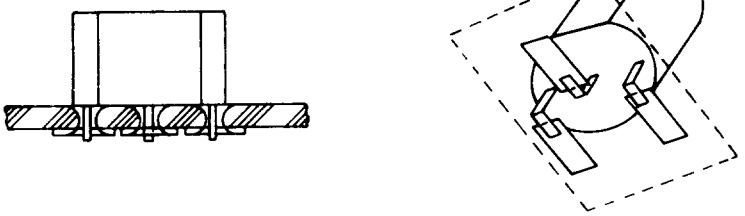


Fig. 6—Mounting of 51- and 66-Type Transistors

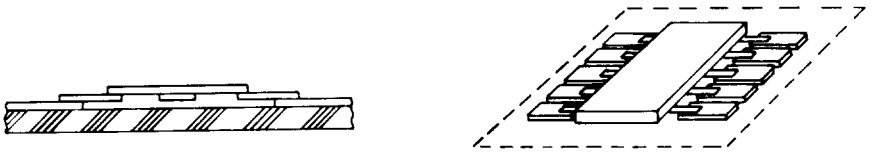


Fig. 7—Mounting of 1-Type Integrated Circuit

evidence of being rough, pasty, or coarsely granular.

4.11 ***Solder Fillets***

(a) Solder fillets shall show evidence of good wetting of both the component lead and the terminal area, with a portion of the lead outlined.

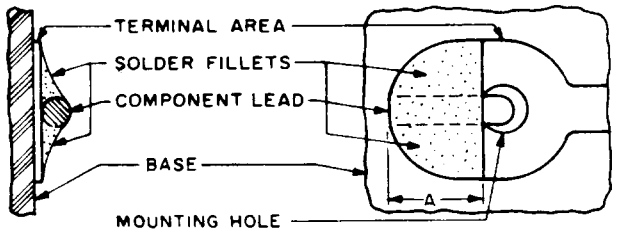
(b) Clinched connections shall be soldered in accordance with Fig. 8. It is not required that the component lead hole be filled with solder.

(c) Nonclinched connections shall be soldered in accordance with Fig. 9. Solder fillets shall total a minimum of 270 degrees around the periphery of the lead, judged visually.

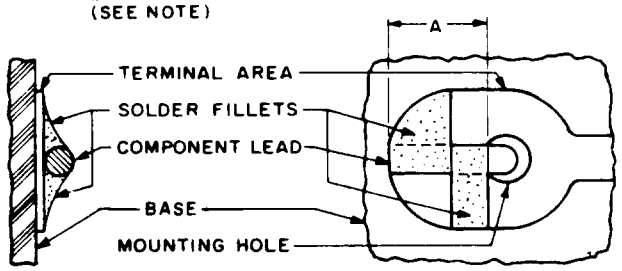
(d) Components, terminals, hardware, or similar items which are fastened to the board by spinning, swaging, or similar operations, and which require electrical connection to the conductor pattern, shall have solder fillets totaling at least 50 percent of the distance around the periphery of the flange, judged visually.

F. Cleaning

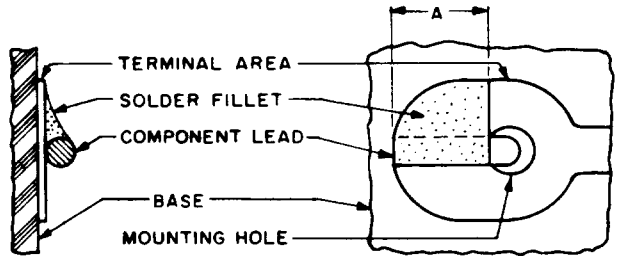
4.12 All printed wiring assemblies shall be cleaned. To avoid impairing the electrical properties of the board, the noncomponent side shall be kept



(a) PREFERRED - TWO SOLDER FILLETS THE FULL LENGTH DISTANCE "A" (SEE NOTE)



(b) MINIMUM ACCEPTABLE - TWO SOLDER FILLETS TOTALING IN LENGTH AT LEAST THE DISTANCE "A". (SEE NOTE)



(c) MINIMUM ACCEPTABLE - ONE SOLDER FILLET FULL LENGTH OF DISTANCE "A". (SEE NOTE)

NOTE: DISTANCE "A" IS 0.06 INCH MIN OR THE DISTANCE FROM THE EDGE OF THE HOLE TO THE EDGE OF THE LAND, WHICHEVER IS SHORTER.

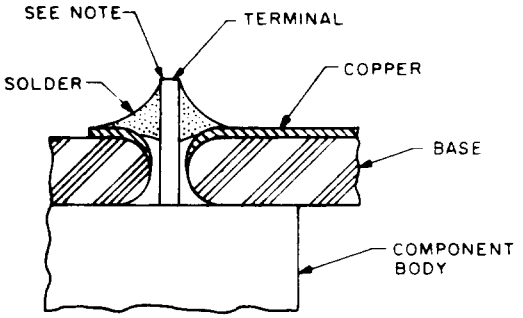
Fig. 8—Requirements for Soldering Clinched Wire Connection

free from dust, fingerprints, grease, and other foreign matter.

G. Modification and Repair

4.13 ***General:*** When it is necessary to modify an assembly to perform an authorized repair operation, the printed wiring assembly shall meet all requirements of Part 4 after the modification or repair is completed.

4.14 ***Open Circuiting:*** When it is necessary to remove a section of the conductor pattern or to create an open circuit, a section no less than 0.06 inch in length shall be removed.



NOTE:
TERMINAL MAY PROJECT BEYOND SOLDER FILLET PROVIDED IT MEETS APPLICABLE UNIT CLEARANCE REQUIREMENTS AND SAFETY REQUIREMENTS OF 4.10 (A)

Fig. 9—Cross-Section of Nonclinched Soldered Wire Connection

4.15 ***Allowable Repairs:*** The number of repairs shall not exceed six per assembly unless a greater number is authorized by the BTL design engineer.

4.16 ***Definition of Repairs:*** Printed wiring board repairs are, by definition, the correction of defects in the conductor pattern (except contact fingers) and the insulating surface of the base. For the purpose of calculating the number of repairs per assembly, the following breakdown applies.

(a) The correction of each discontinuity per 4.17, or lifted conductor pattern per 4.18, is one repair.

(b) The correction of defects in one terminal area, regardless of the number of connections made to it, is one repair.

(c) The correction of defects in any number of terminal areas associated with a single component is a total of one repair.

(d) Restoration of designations per 4.19 shall not count in determining the total number of repairs.

(e) Repairs to the base per 4.21 shall not count in determining the total number of repairs.

4.17 ***Repair of Discontinuities:*** A conductor path discontinuity per 4.01 (a) shall be repaired by one of the following methods.

(a) If the discontinuity is 0.13 inch or less, it may be repaired with bare tinned copper wire (26 AWG minimum) soldered to the conductor path. The wire and solder fillets shall extend at least 0.13 inch on each side of the discontinuity. No repair shall reduce spacing to less than the allowable minimum.

(b) Run an insulated copper wire (26 AWG minimum) between plated-through holes at each end of the damaged conductor path. Solder each end, and secure the wire to the board with epoxy per 4.18. If it is not practicable to use existing holes, new holes may be drilled. Care must be taken to insulate the added conductor from the base metal.

4.18 ***Repair of Lifted Conductor Pattern:*** A lifted or missing portion of the conductor pattern per 4.01 (b) and (c) shall be repaired by one of the following procedures.

(a) ***Lifted***

(1) Clean the damaged area per 4.12.

(2) Cover the damaged area and an area of at least 0.13 inch around it with an epoxy compound per Material Specification 58456, Type 5A, or an approved equivalent. Do not handle until the epoxy has hardened.

(b) ***Missing:*** When a terminal area is completely lifted or is missing, it may be repaired as follows:

(1) Wrap at least one full turn of bare tinned copper wire (26 AWG minimum) around the compound lead. Lay the other end of the wire at least 0.13 inch along the conductor path and solder. Minimum spacing requirements shall not be violated.

(2) Cover the portion soldered to the conductor path with epoxy per (a).

4.19 ***Repair of Designations:*** Obliterated or missing characters shall be replaced (when required) per 3.21.

4.20 ***Repair of Plated-Through Holes:*** A defective plated-through hole may be repaired by means of a clinched wire interfacial connection per X-17753 made through the defective hole, clinched and soldered to the terminal areas on both sides of the board.

4.21 ***Repair of Base:*** Voids or scratches in the resin which extend to the base metal shall be filled with epoxy.

5. DEFINITIONS

5.01 ***Resin-Coated Metal Printed Wiring Board:*** A printed wiring board whose base is formed of metal coated with an insulating resin, and whose conductor pattern is formed by metal deposition.

5.02 ***Printed Wiring Assembly:*** A printed wiring board to which component parts have been assembled, secured, and electrically connected.

5.03 ***Conductor Pattern:*** The total combination of conductor paths, terminal areas, and contact fingers.

5.04 ***Conductor Path:*** The portion of the conductor pattern on the surface plane which provides point-to-point electrical connections between terminal areas and/or contact fingers.

5.05 ***Terminal Area:*** The portion of the conductor pattern used for making electrical connections to conductor paths and component leads.

5.06 ***Contact Finger:*** The portion of the conductor pattern intended for mating with external pressure contacts for purposes of electrical connection.

5.07 ***Base:*** The insulated metal support for the conductor pattern.

5.08 ***Component Side:*** The side of a printed wiring board upon which the majority of the components are mounted.

5.09 ***Noncomponent (Conductor) Side:*** The side opposite to the component side.

5.10 ***Clinched Connection:*** A connection to a printed wiring board in which a component lead or wire is inserted through a hole in the base

and is subsequently bent over for purposes of making a soldered connection.

5.11 ***Nonclinched (Unclinched) Connection:*** A connection to a printed wiring board in which a component lead or wire is inserted through a hole in the base and is not subsequently clinched.

5.12 ***Surface Connection:*** A connection to a printed wiring board in which a lead or conductor does not extend through the base.

5.13 ***Interfacial Connection:*** An electrical connection between conductor patterns on opposite sides of a printed wiring board and/or between a conductor pattern and the metal portion of the base.

5.14 ***Jumper (Strap):*** A direct electrical connection, which is not a portion of the conductor pattern, between two points on the same printed wiring plane.