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Subject: Printed Wiring Board Assembly

APPROVED BY Manager, Hardware Engineering

STATUS Maintenance Revision

PURPOSE Establish the requirements for the assembly of components on a printed wiring assembly for all military and commercial products, and incorporate applicable requirements of MIL-P-28809 and IPC-A-610.

This instruction shall be utilized by L-3 Communications Corporation, Link Simulation & Training Division (hereafter referred to as Link) Manufacturing for the assembly requirements of printed wiring assemblies. This instruction also applies to Support Operations/Field Service personnel for maintenance/rework of printed wiring assemblies.

NOTE

Certain portions of this instruction are noted as not being applicable to Support Operations/Field Service personnel, due to the fact that they do not have the necessary tooling and processes in the field to perform that portion. If the noted portions of the instructions are required to be performed in the field, the board assembly will need to be returned to the Plant or Depot.

AFFECTED FUNCTIONS Hardware Engineering
Manufacturing

REFERENCES

LMS 1-2	Rework Procedures
LMS 1-4	Modification of Printed Wiring, Multilayer, or Multiwire Assemblies
LMS 11-3	Hand Soldering, Electrical
LMS 11-20	Keying
IPC-CC-830	Qualification and Performance of Electrical Insulating Compound for Printed Circuit Assemblies
J-Std-004	Requirements for Soldering Fluxes
MIL-I-46058	Insulating Compound, Elec. (For Coating Printed Circuit Assemblies)
MIL-C-28809	Printed Wiring Assemblies
MIL-STD-275	Printed Wiring for Electronic Equipment

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QQ-S-571	Solder; Tin Alloy, Lead Tin Alloy, and Lead Alloy
IPC-A-610	Acceptability of Electronic Assemblies

DEFINITIONS

Bow. The deviation from flatness of a board characterized by a roughly cylindrical or spherical curvature such that, if the board is rectangular, its four corners are not in the same plane.

Crazing. An internal condition occurring in reinforced laminate base material whereby glass fibers are separated from the resin at the weave intersection. (This condition manifests itself in the form of connected white spots or crosses below the surface of the base material. It is usually related to thermally induced stress.)

Delamination. A separation between plies within the base material, between the base material and the conductive foil, or any other planer separation within a multilayer printed board.

Interfacial connection. A conductor that connects the conductive patterns on both sides of a printed board. For example, a plated-through hole.

Measling. An internal condition occurring in laminated base material in which internal glass fibers are separated from the resin at the weave intersection. (This condition manifests itself in the form of discrete white spots or crosses that are below the surface of the base material. It is usually related to thermally induced stress.)

Plated-through hole. A hole with plating on its walls that makes an electrical connection between conductive patterns on internal layers, external layers, or both of a printed board.

Solder plug. A core of solder in a plated-through hole.

Unsupported hole. A hole in a printed board that does not contain plating.

Wetting, solder. The formation of a relatively uniform, smooth, unbroken, and adherent film of solder to a base metal.

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INSTRUCTION

1. Requirements

1.1 Materials.

a. Solder. The solder used shall be in accordance with composition Sn 60, Sn 62, or Sn 63 of QQ-S-571. For wave or dip soldering, use bar solder, form B. For hand soldering, use solder wire, form W, either solid metal, type S, or with a core of flux, type RMA of QQ-S-571, only.

b. Flux. Liquid flux used for soldering shall be a non-corrosive, rosin-base flux conforming to the requirements of MIL-F-14256, type R or type RMA. Water soluble fluxes shall not be allowed for soldering.

When necessary, flux may be thinned with vendor-recommended flux thinner.

c. Buffer material. The buffer material, when required, shall be a thin pliant material such as polyvinylidene fluoride, polyethylene terephthalate, or silicon rubber, and be non-reactive with the conformal coating, solder mask, all materials, and all components to which it comes in contact. The buffer material shall be fungus and flame resistant and clear or transparent so markings on the components are visible.

d. Conformal coating. Conformal coating material shall be as specified on the approved assembly drawing and shall be in accordance with IPC-CC-830 or MIL-I-46058. Solder mask shall not be considered as conformal coating. The type of conformal coating shall be as listed on the assembly drawing. The conformal coating shall be compatible with the solder mask.

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1.2 Printed Wiring Board.

a. Measling and crazing. As long as the assembly is functional measling and crazing are acceptable.

b. Delamination, blistering, or softening. There shall be no delamination, blistering, or softening of the plastic materials.

c. Marking. Printed wiring assemblies shall be marked as specified on the assembly drawing(s). All assemblies shall be serialized for traceability.

d. Keyways for printed wiring boards. Keyways, when specified on the assembly drawing, must be made before populating the board with components. Keyways may be beveled to facilitate alignment with connector polarization keys. The bevel shall be limited to the tapered edge of the board. (See Figure 1.) All keying shall conform to **LMS 11-20**.

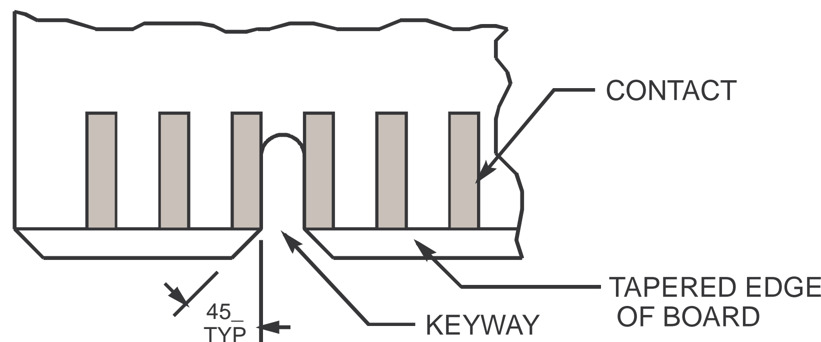

Figure 1 Printed Wiring Board Connector Keyways

1.3 Assembly. All printed wiring assemblies shall be handled as if they contain Electrostatic Discharge Sensitive (ESDS) Devices. All assemblies shall be handled in accordance with the procedures as defined in The L-3 on line ESD training.

a. Eyelets. When specified on the assembly drawing, eyelets shall be installed in accordance with Figure 2. Eyelets shall not be used for interfacial connections.

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Eyelets insertion. Eyelets shall be inserted so that funnelling is accomplished only on the copper-clad side(s). (See Figure 2.) Eyelets shall be rolled or funnelled loosely onto the board. The rolling or funnelling operation shall be such that upon shaking the board by hand, the eyelets are free to move. This is necessary to prevent marring, delamination, and cracking of the board due to thermal expansion of the material while soldering and assembling. Splits or cracks are acceptable in the funnelled or rolled area providing they do not extend into the barrel or body diameter.

b. Stand-off terminals. When specified on the assembly drawing, stand-off terminals shall be installed as shown in Figure 3.

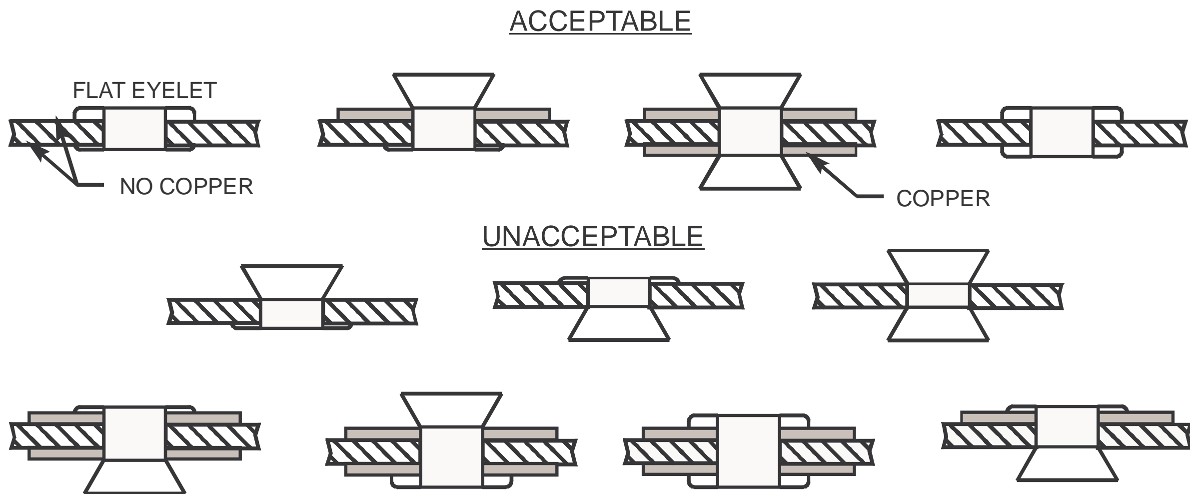

Figure 2 Installation of Eyelets

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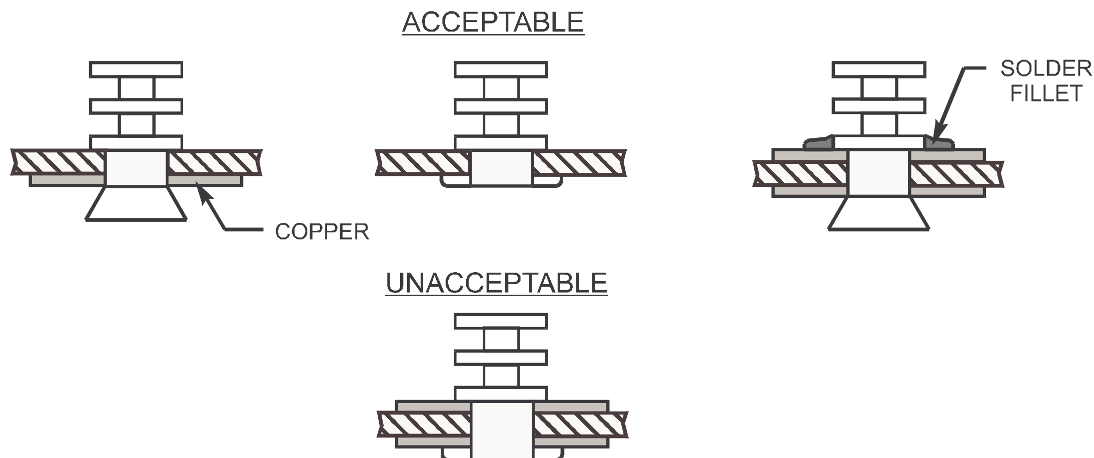

Figure 3 Installation of Stand-off Terminals

c. Orientation of markings on parts being mounted. Unless impossible orientation of parts shall be such that polarity markings, part number are visible. When visibility of only some of the markings is possible, visibility of polarity and functional markings shall take precedence over visibility of other type markings.

d. Critical components. Due to use of critical semiconductors, such as high-speed transistors and low-thermal junction diodes, it is imperative that precautions be taken to prevent heat damage during assembly. When specified by the assembly drawing, heat-sensitive components shall be attached by controlled hand soldering.

e. Component leads.

(1) Solderability. All materials with surfaces to be soldered shall be solderable at the start of manual or machine soldering operations.

(2) Lead forming. Leads shall be formed so that no strain is placed on the component while bending the lead. Wire-bending pliers or other devices may be used to form component leads. Long-nose pliers are considered to be an acceptable bending tool, provided the teeth or sharp edges of the jaws are covered with durable tubing or plastic tape and do not nick, ring, or otherwise

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damage the lead to the extent that the bare base metal shows on the lead. Leads may also be formed by machine or by hand over special forming blocks. A typical forming block is shown in Figure 4.

(a) The minimum lead bend radius shall be as shown in Figure 5.

(b) Lead forming shall be no closer to the component body than the limits shown in Figure 5.

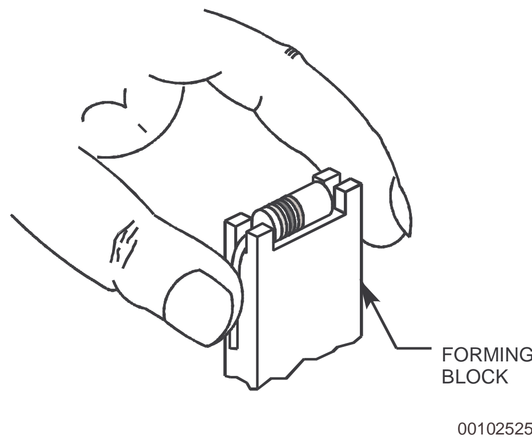
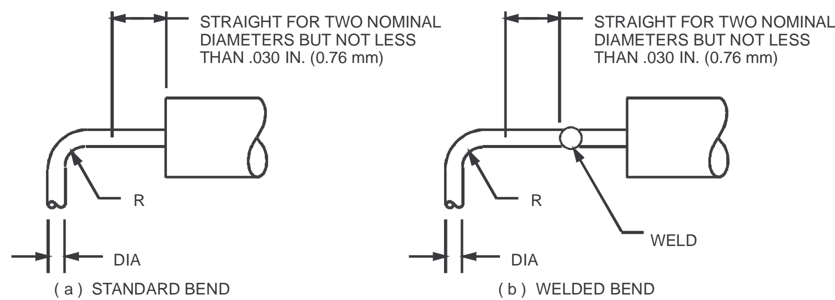


Figure 4 Component Lead Forming



NOMINAL LEAD DIAMETER IN INCHES (mm)	MINIMUM RADIUS (R) IN INCHES (mm)
Up to .027 (0.690)	Nominal lead diameter
from .028 to .047 (0.71 to1.194)	1.5 times nominal diameter
.048 (1.219) and larger	2.0 times nominal diameter

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Figure 5 Lead Bend

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(3) Lead damage. Leads shall not be nicked, ringed, scraped, or damaged to the extent that the bare base metal shows on the lead or reduces the cross-sectional area of the lead by more than 10 percent. Except as noted on the assembly drawing, the bare base metal is permitted at the end of a trimmed lead or wire. (See Figure 6.)

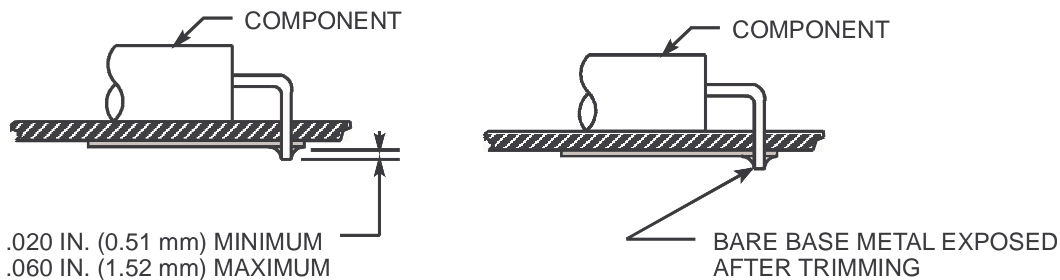

Figure 6 Component Lead Trimming and Extension

(4) Lead trimming. Unless noted otherwise on the assembly drawing, component leads may be either crimped or protrude straight through the board, as determined by the Industrial Engineer.

(a) Straight-through leads in both plated-through and unsupported holes. When straight-through leads are used in conjunction with unsupported holes, the leads should extend from .020 inch (0.508 mm) minimum to .060 inch (1.524 mm) maximum from the surface of the foil. When straight-through leads are used in conjunction with plated-through holes or eyelets, the lead should extend at least to the surface of the plating or rim of the eyelet and no more than .060 inch (1.524 mm) from the plating surface eyelet. (See Figure 6.) Leads of microelectronic components mounted through holes in printed wiring need not extend beyond the plated surface of the board provided the lead can be seen in the soldered joint.

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(b) When component leads are crimped, crimping may be done manually or by machine at the discretion of Industrial Engineering. Manually crimped leads should be formed to lie parallel to the conductor and shall be cut not less than .031 inch (0.0787 mm) nor more than .188 inch (4.775 mm) long, as measured from the center of the mounting hole. (See Figure 7.) At times, it may be necessary to crimp the leads in a direction other than parallel to the conductor in order to prevent components from falling out prior to soldering. The trimmed lead end shall not reduce the required clearance with an adjacent trace, pad, or lead. The lead or termination shall make contact with the conductor pattern. The lead termination hole may be supported by eyelets or plated-through holes, or it may be unsupported.

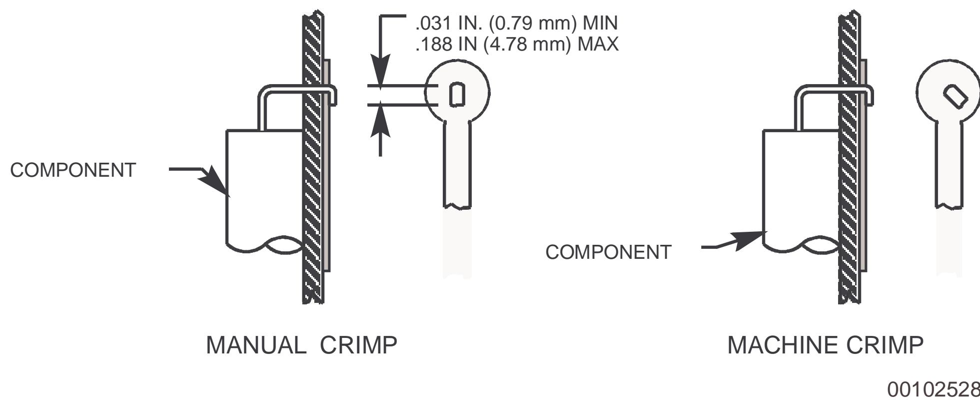

Figure 7 Trimming of Component Leads

(c) Tempered lead cutting on printed circuit assemblies whose component leads are not designed to be cut or clinched (not intended for lead clinching or cut off), such as modules, integrated circuits, connectors, test jacks, relays, potentiometers, sockets, etc., will be governed by the maximum dimensions on the engineering drawing.

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(5) Gold-plated leads and wires. Except for leads and/or wires that are gold plated with less than 100 micro inches of gold plating, all gold plated leads and/or wires which are to be soldered shall have the gold removed before soldering by single or double dipping into a flowing or non-flowing hot solder, respectively, of sufficient volume to assure gold removal.

(6) Un-insulated lead wires. Any un-insulated lead wire that can come in contact with any conductive surface shall be protected by a piece of insulating sleeving.

f. Part mounting.

(1) Centering. The body of the component should be centered as close as possible between tie points and mounting clips when used. For minimum requirements see paragraph 1.3e(2)(b).

(2) Location. Each part shall be mounted in the location specified on the assembly drawing. All parts shall be correctly located, oriented, mounted, and attached.

(3) Component support.

Component leads shall not exceed 1 inch (2.54 cm) or be less than .030 inch (0.762 mm) from the body to the point of attachment unless the component is secured.

(4) Perpendicular mounting. Axial-leaded components weighing less than .50 ounce (14 g) may be mounted on the assembly using perpendicular mounting criteria. The assembly drawing shall prescribe a minimum of .010 inch (0.254 mm) space between the end of the component body (or the lead weld) and the board. Unless otherwise noted on the assembly drawing, components requiring perpendicular mounting shall be installed with their major axis within 15 degrees maximum of a right angle with board surface. The maximum vertical height from the board surface shall be .55 inch (13.970 mm). (See Figure 8.)

Spacers. For ease of manufacturing and to maintain spacing when mounting axial lead components perpendicular to the

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board surface as specified in paragraph 1.3f(4) or non-axial lead components as specified in paragraph 1.3f(5), nylon spacers (Link PN 1007696-XXX) or equivalent may be used.

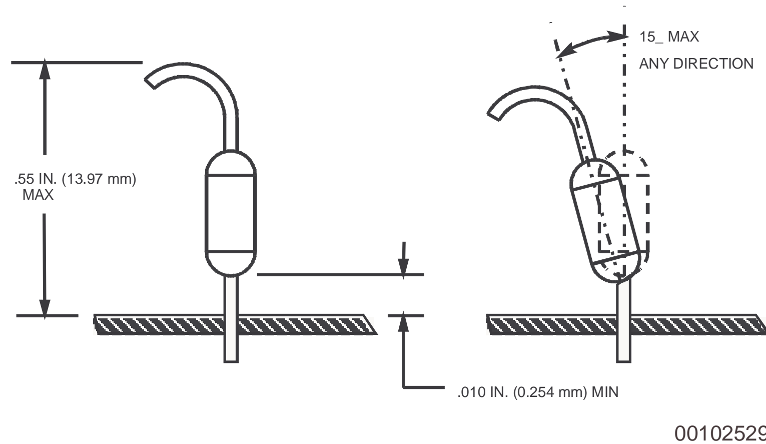

Figure 8 Perpendicular Part Mounting

(5) Part body clearance. For non-axial lead components (transistors, integrated circuits, capacitors, and the like with rigid or fixed leads) without built-in or other type spacers, the surface from which the leads project shall be a minimum of .01 inch (0.254 mm) above the plated, conductive surface of the board to facilitate subsequent soldering, cleaning, and coating operations. If design limitations require placement of parts over conductive areas, the part shall be mounted so that subsequent insulating coating will cover the conductive area under the part, or conductive areas under parts shall be insulated or protected against moisture entrapment by solder mask over the area prior to mounting the part.

(6) Multiple-leaded parts. Multiple-leaded parts (components with three or more leads), except multiple-leaded components mounted to thermal planes or heat sinks, shall be mounted in such a manner that spacing is provided under the body of the part to facilitate cleaning. (Required only prior to wave solder process.)

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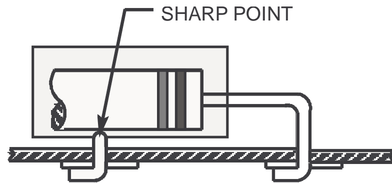
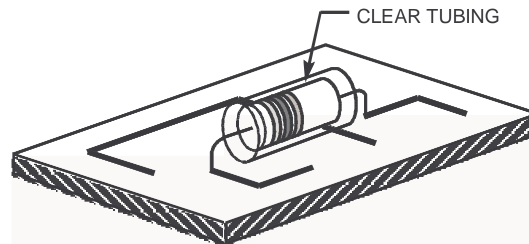
(7) Metal-cased parts. Metal-cased components insulated from the printed wiring boards with clear sleeving shall not come in contact with sharp solder connection points. (See Figure 9.)





NOT RECOMMENDED
SLEEVED COMPONENT MOUNTED OVER SHARP SOLDER CONNECTION POINT.

RECOMMENDED
METAL-CASED COMPONENT INSULATED FROM PRINTED WIRING WITH CLEAR SLEEVING, NOT MOUNTED OVER SHARP SOLDER CONNECTION POINT.

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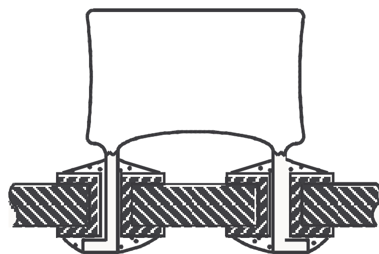
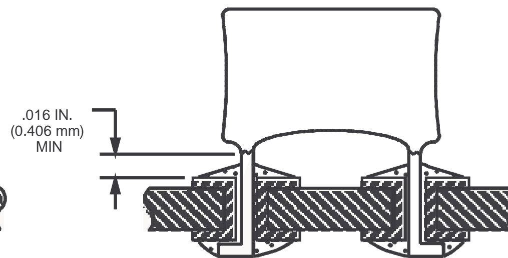
Figure 9 Mounting of Metal-cased Components

(8) Coated, sealed ceramic or plastic parts. Coated or sealed ceramic or plastic components shall be mounted so that the coating or sealing material does not enter the solder joint area. Components installed in plated-through holes shall maintain a minimum clearance of .016 inch (0.406 mm) between the surface of the circuitry and the end of the lead coating. (See Figure 10.)





NOT RECOMMENDED
COATING ON LEAD EXTENDS INTO SOLDER JOINT.

RECOMMENDED
COATING ON LEADS HAS MINIMUM CLEARANCE OF .016 IN. (0.406 mm) ABOVE CIRCUITRY.

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Figure 10 Vertical-mounted Components

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(9) Heat sink compound. When specified on the assembly drawing for mounting transistors and diodes, apply a thin coating of heat sink compound similar to Link PN 479469 or Link PN 432434. The compound shall be applied with an applicator to the following:

(a) The base and mounting stud.

(b) Both sides of the insulating washer, when used.

(c) Any surface of the transistor or diode that contacts the heat dissipater.

(10) Attaching heat sink to printed wiring board. (Not applicable to Support Operations/Field Service personnel.) When specified on the assembly to attach a heat sink utilizing Ablefilm 561K adhesive, Link PN 8564493- 001, the following process shall be used and shall be performed prior to mounting any electrical components:

(a) Cut the adhesive film with a sharp knife to match the mounting surface of the heat sink.

(b) Place the adhesive film between the heat sink and printed circuit board and position on the board.

(c) Apply a weight or clamp that will maintain a minimum of one psi during the curing cycle to the assembly.

(d) Place the assembly in a preheated oven at 302°F (150°C) for 30 minutes.

(e) A heat sink that has been attached using Ablefilm may be removed by reheating to 302°F (150°C) and sliding a thin blade between the bonded surfaces.

CAUTION

Avoid prolonged skin contact with the Ablefilm adhesive. If contact does occur, wash area immediately with soap and water.

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(11) Connectors. The following procedure shall be used for applying connector pins to printed wiring assemblies:

(a) Connectors of the Elco type (individual contacts) shall be swaged, crimped, or staked to assure a firm mechanical and electrical connection prior to soldering.

(b) Contacts shall not be movable by hand prior to soldering.

(c) Contacts shall be aligned and parallel to each other.

(d) Contacts shall be affixed to the board prior to the insertion or assembly of other components.

(12) Extender card connectors. Connectors that are soldered to an extender card shall conform to the requirements in Para. 1.4 for planer-mounted devices.

(13) Wire terminations. Wires terminating in a mechanical disconnect (terminal lug) on printed circuit assemblies shall be identified on the lug end by an identification sleeve. (See Figure 11.) In those cases where one end of the wire is soldered into the printed circuitry, and the other end connects at a mechanical termination point such as a mounting screw, only the mechanical termination identification will be marked on the sleeve. When both ends of the wire terminate with mechanical disconnects, the sleeve shall employ a dual identification to indicate both termination points. Due to the relatively short length of wire used on printed circuit assemblies, only one sleeve will be required on each wire.

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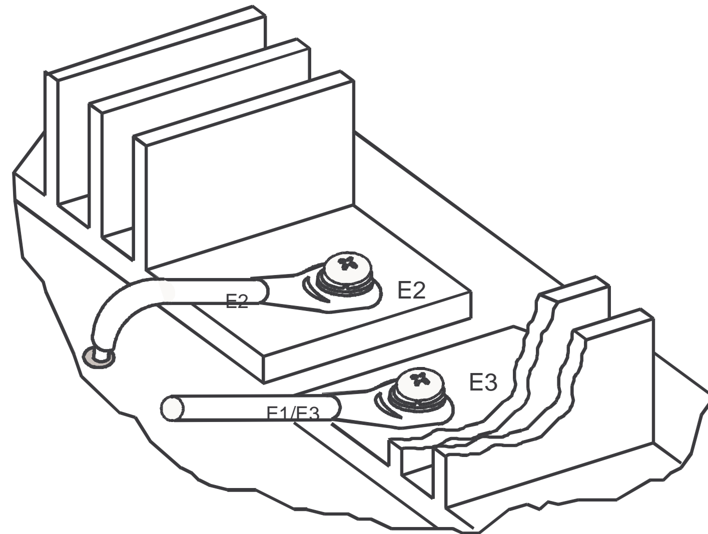

Figure 11 Wire Identification

(14) Jumper wires. Jumper wires shall be as short as practical and shall not be applied over or under the bodies of other components.

(15) Wire- wrap circuit cards. The dressing of wires on wire-wrap printed wiring boards shall provide maximum possible accessibility to all parts and components. In particular, wires shall not be dressed over dual in-line packs. (See Figure 12.)

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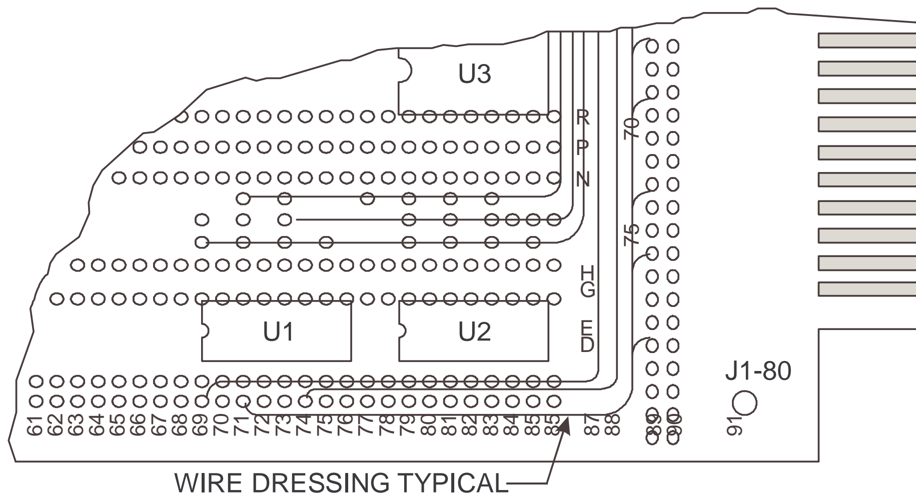

Figure 12 Wire Dress on Wire Wrap Circuit Cards

1.4 Soldering. (Only those portions pertaining to Hand Soldering shall apply to Support Operations/Field Service personnel.)

a. General. Soldering shall be in accordance wit IPC –A-610, as specifed herein. Several methods of soldering are acceptable for printed circuit board assembly soldering. The method used must produce a clean through joint, penetrating well up and around a component lead with the outline of the lead discernible through the solder.

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NOTE

Unused plated-through holes and plated-through holes with unused wirewrap pins on all printed circuit basic boards described on the following drawings are exempt from the requirements of paragraph 1.4 and its subparagraphs. (When the boards are revised, those areas changed must meet LMS 4-1.)

2014081	2010953	2058654	2070654
2014082	2072805	2010980	
2010874	2080723	2062430	

b. Flux application. When used, liquid flux shall be applied in a thin, even coat to those surfaces being joined prior to the application of heat. Cored wire solder shall be placed in such a position that the flux can flow and cover the joint as the solder melts. Flux shall be applied so that no damage will occur to the surrounding parts and materials, And should also meet the requirements of J-STD-004 flux type LO or LI.

c. Securing of parts. Proper securing of parts to be soldered shall be provided in order to hold parts in uniform proximity to assure repeatable soldering results.

d. Masking. Surfaces that are to remain free of solder shall be protected from contact with the molten solder.

e. Applying heat/solder. The areas to be joined shall be heated to the correct temperature for the correct length of time to make the joint. Excessive time (slow heating) and excessive temperature shall be avoided to prevent causing unreliable solder joints and damaged parts.

(1) Heat sinks shall be used for the protection of parts, if required. Parts, wire insulation, or printed circuit boards that have been charred, melted, burned, or discolored shall be replaced.

(2) When the solder pre-placement methods are used (i.e., pre-forms, pastes, etc.), the solder is applied to the joint area prior to heating. Additional solder may be added to the parts being soldered prior to, or during, the soldering or re-flow operation.

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f. Cooling. No liquid shall be used to cool a soldered connection. Heat sinks may be used to expedite cooling. The connection shall not be subjected to movement or stress at any time during the cooling and solidification of the solder. Controlled air cooling may be used before or after the solder has solidified, provided that neither the solder joint nor the assembly are adversely affected.

g. Post-soldering cleaning. Printed wiring assemblies shall be cleaned within one hour after application of soldering flux using solvents or combinations of solvents or other solutions which will remove polar and non-polar contaminants. After cleaning there shall be no visual evidence of flux residue or other contaminants. Other contaminants include solder splash, clippings, solvent film, dirt, oil, fingerprints, salts, corrosion, or any other foreign material which may result in insulation breakdown, change in electrical characteristics, or degradation of mechanical integrity (e.g., improper bonding of conformal coating). This solder cleaning requirement shall also apply after rework. Subsequent handling should not contaminate the assembly prior to final cleaning and conformal coating.

NOTE: Ultrasonic cleaning may damage certain parts, particularly transistors, and should generally be avoided.

h. Manual/hand (non-reflow) soldering. (See **LMS 11-3**.) After applying heat, the solder shall be applied to the joint and not to the soldering iron; however, a very small quantity of solder may be applied at the place where the iron tip touches the joint to improve heat transfer. Soldering iron tips must be maintained by re-tinning the tip upon return to the soldering iron holder.

i. Lead cutting after soldering. The cutting of component leads or wires after soldering shall be followed by the re-flow of the solder connection.

j. Acceptability. The following figures (Figures 13 through 21) indicate the requirements for acceptable solder connections. All solder connections shall meet the requirements of these figures.

k. Solder plugs. Solder shall be applied to component leads and to the assembly to create a continuous solder plug around the component leads in the plated through-holes and eyelets. In addition, boards subjected to

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wave or dip soldering are to be processed to fill any typical plated through-hole that is not intended to accept a lead attachment with a solid plug of solder.

(1) As a minimum, solder plugs shall be required in:

(a) All electrically functional and nonfunctional plated through-holes with a lead; the lead is required to be surrounded 360 degrees by the solder plug throughout the length of the plated through-hole no matter what technique for soldering is used.

(b) Any plated through-hole without a lead that is subject to wave or dip soldering and not exempted by (2)(c) or (2)(d) below.

(2) Solder plugs are not required in:

(a) Any unsupported hole without a lead.

(b) Any electrically functional or nonfunctional plated through-hole (without a lead) when methods other than wave or dip soldering are used.

(c) Any plated through-hole covered with polymeric cover layer (not conformal coating) or previously filled with an appropriate polymer in order to prevent hole access during wave or dip soldering.

(d) Any plated through-hole, electrically functional or not, without a lead, where access to the hole is limited by component body, heat sinks, by design (blind vias), and where access of solder to the hole is prevented during the solder process.

NOTE

In the event solder plugging due to natural capillary action is not possible, such as when a heat sink is bonded directly over the plated through-hole, the assembly processor shall block these holes with some temporary technique that will prevent solder and flux access to the holes. Such techniques must have sufficient durability not to break up when

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exposed to the soldering process, yet be fully removable before the assembly is complete.

(e) Plated-through holes without leads, after exposure to wave, dip, or drag soldering equipment, shall meet all the acceptability requirements of Figure 13, provided that 98 percent of the holes are represented by the conditions shown in “A” through “E” of Figure 13 and 2 percent represented by the conditions shown in “F”.

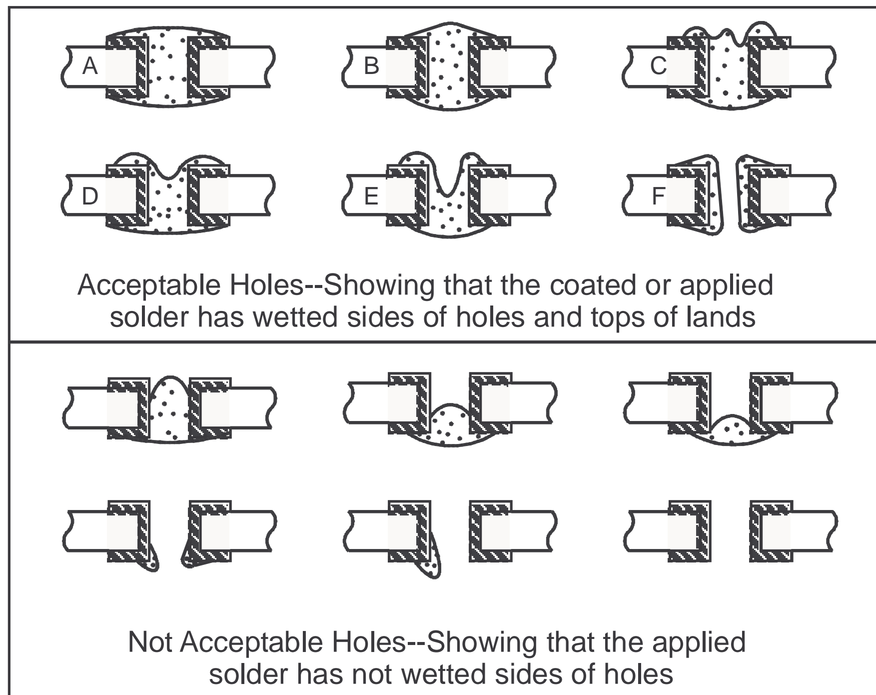

Figure 13 Effectiveness of Solder Wetting of Plated-through Holes

NOTE

Effectiveness of Solder Wetting of Plated-through Holes. Plated-through hole walls sometimes cause the formation of blowholes by the evolution of gaseous products during the heating cycle of soldering. Such evolution is often visible during soldering and also after soldering as voids left in the solidified metal. This outgassing of material is a separate issue from the ability of the hole wall to be wet by solder. The solder coating shall also be homogenous and cover the conductor.

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l. Solder connections. Solder connections shall indicate evidence of wetting and adherence when the solder blends to the soldered surface, forming a small contact angle with no more than 10 percent of the periphery of the solder connection being non-wetted or de-wetted; this insures the presence of a metallurgical bond and metallic continuity from solder to surface. (See Figure 14.)

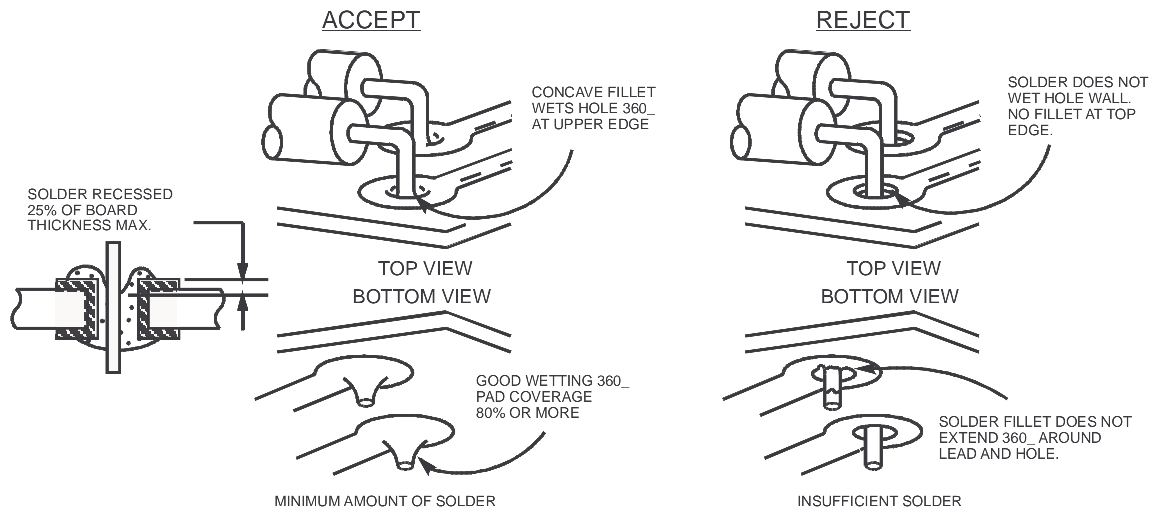

Figure 14 Solder Wetting

m. Voids. Smooth clean voids or unevenness on the surface of the solder fillet or coating shall be acceptable. (See Figure 15.) A smooth transition from land to connection surface or component lead shall be evident. The solder connection from a plated-through hole to a component lead may occur in the hole without exterior build-up, provided that wetting of the wall and lead surface is evident. A line of demarcation or transition zone where applied solder blends with solder coating, solder plate, or other surfaces shall be acceptable, providing that wetting is evident.

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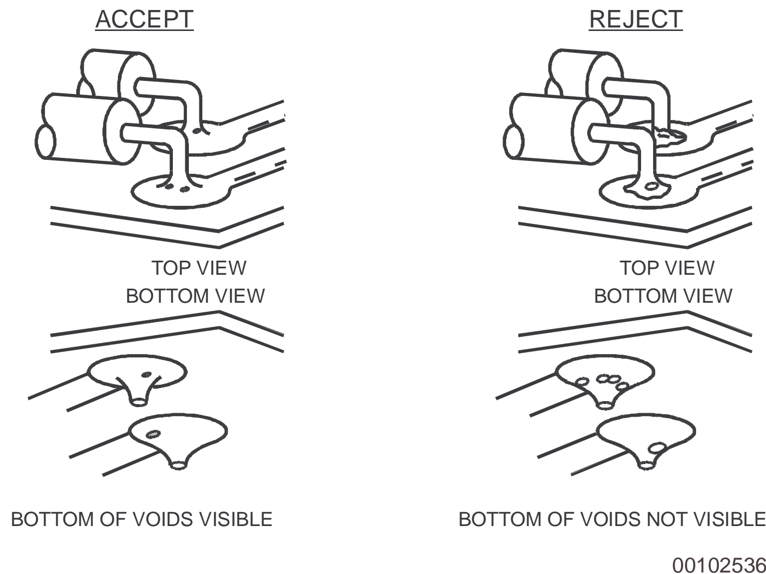

Figure 15 Voids

n. Solder fillets. Solder shall not extend beyond the land. Solder thatextends into lead bend radius of horizontally mounted axial-leaded components is acceptable only into the lead bend radius on one lead of the component (the lead which is closest to the board). (See Figure 16.) The solder connection shall indicate evidence of wetting and adherence when the solder blends to the soldered surface, forming a small contact angle; this indicates the presence of a metallurgical bond and metallic continuity from solder to surface. Smooth clean voids or unevenness on the surface of the solder fillet or coating shall be acceptable. A smooth transition from land to connection surface or component lead shall be evident. The solder fillet should appear to be concave. The solder connection from a plated-through hole to a component lead may occur in the hole without exterior buildup, provided that wetting of the wall and lead surface is evident. A line of demarcation or transition zone where applied solder blends with solder coating, solder plate, or other surfaces shall be acceptable providing that wetting is evident.

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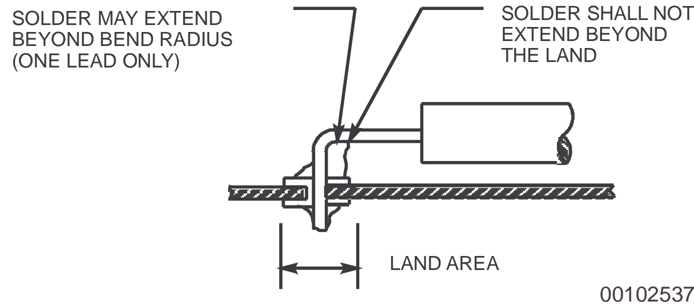

Figure 16 Solder in Bend Radius

Figure 17 Solder Requirements for Clinched Leads in Non-plated-through Holes

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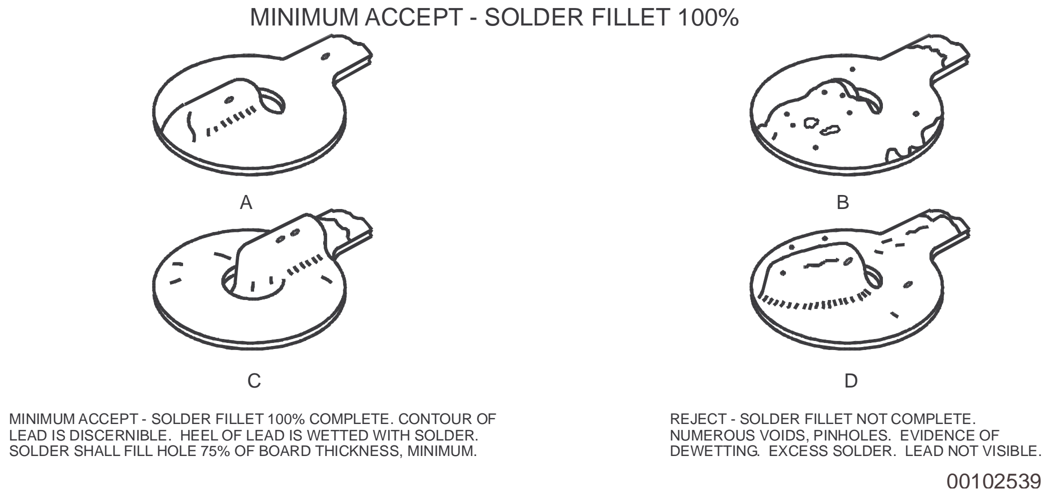

Figure 18 Solder Requirements for Clinched Leads in Plated-through Holes

p. Straight-through, partial clinch, or swaged leads. The end of the straight-through lead need not be covered with solder, but shall be discernible in the solder. Kovar or other iron-based alloys shall be covered with solder. Solder depression is permitted only on one side of the board. (See Figures 19, 20, and 21.)

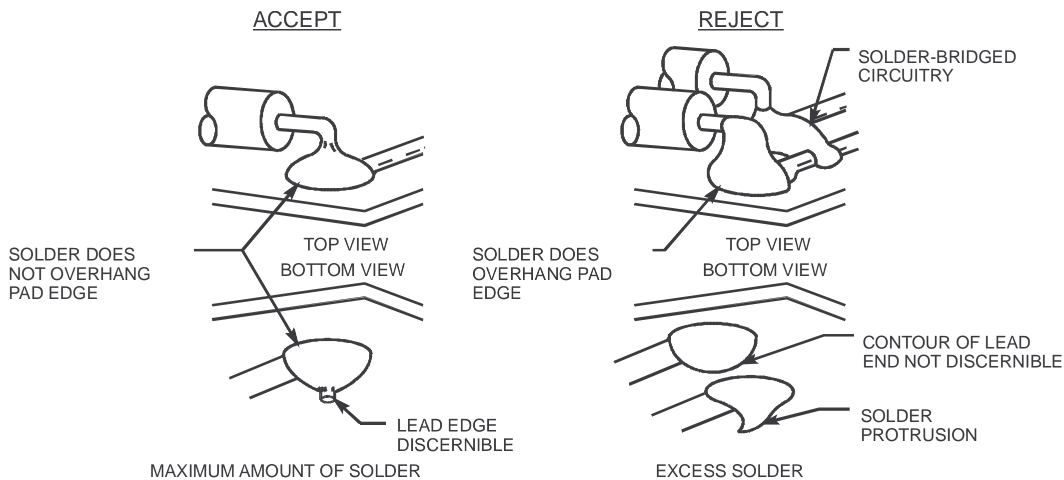

Figure 19 Maximum Amount of Solder on Joint

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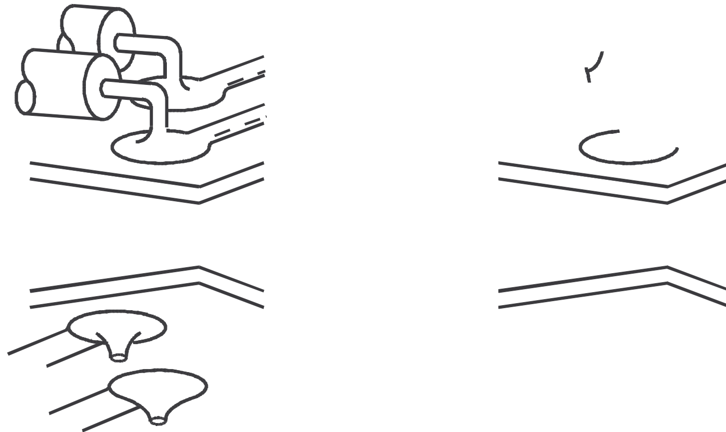

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