



NOTE

All numerical values are in metric units [with U.S. customary units in brackets]. Dimensions are in millimeters. Unless otherwise specified, dimensions have a tolerance of ± 0.13 and angles have a tolerance of $\pm 2^\circ$. Figures and illustrations are for identification only and are not drawn to scale.

1. INTRODUCTION

This specification covers the requirements for application of SlimSeal SSL connectors and contacts for printed circuit (pc) board and free-hanging applications. The connectors consist of vertical and right-angle pin headers available in 2 through 4 contact positions and receptacle and plug housing available in 1 through 4 contact positions. Connector contact cavities are marked with numbers to provide circuit identification.

When corresponding with personnel, use the terminology provided in this specification to facilitate your inquiries for information. Basic terms and features of this product are provided in Figure 1.

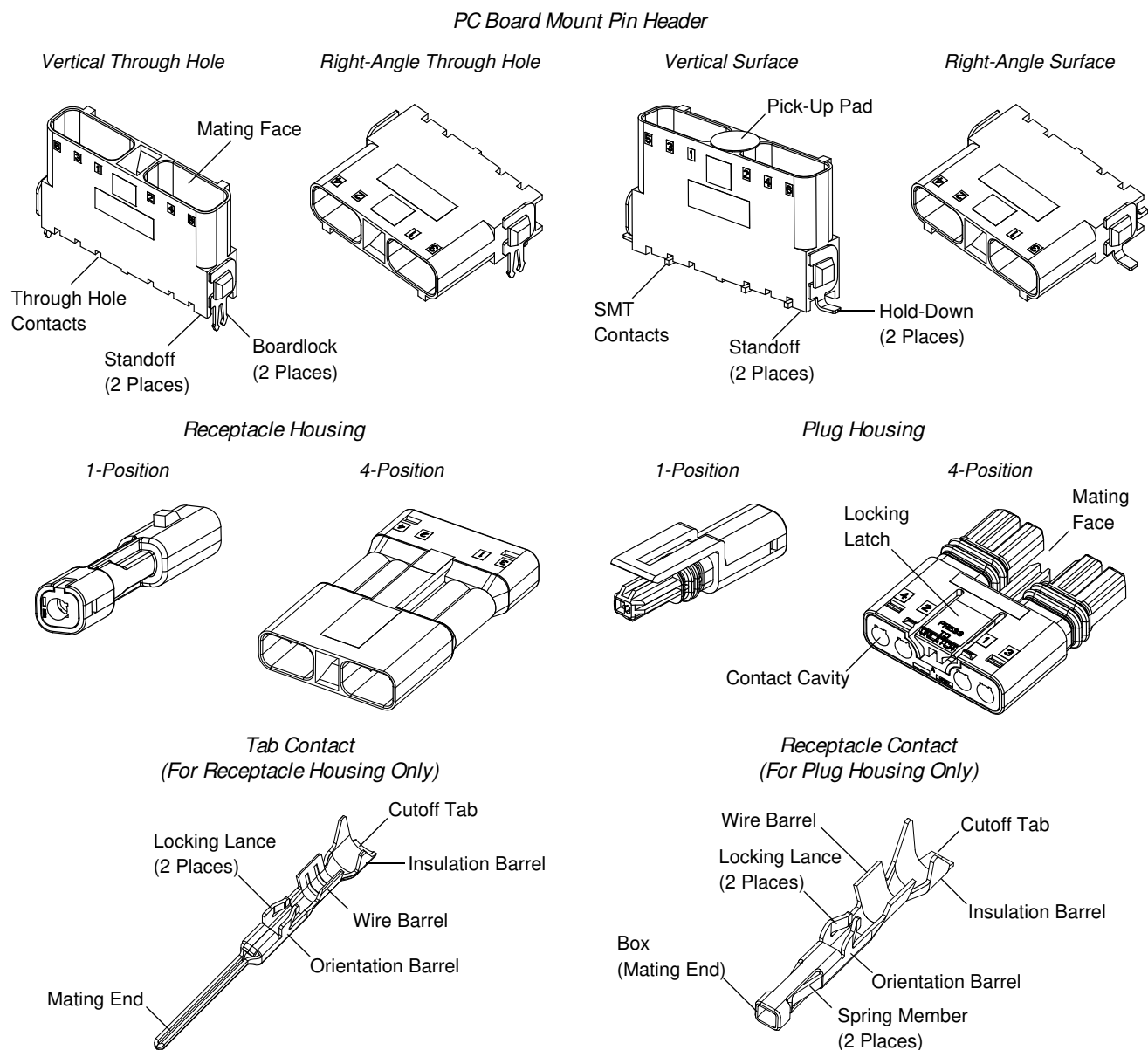


Figure 1

The vertical pin header is available for wire-to-wire application and the vertical and right-angle pin headers are available for wire-to-board application in through-hole mount or surface mount technology (SMT). Each pin header contains pre-installed solder-type contacts with precision formed solder tines. The vertical surface mount pin header features an adhesive-backed pick-up pad on the top of pin header to facilitate vacuum pick-up and handling. Each pin header features standoffs for proper seating and boardlocks (through hole mount) or hold-downs (surface mount) to provide stability for placement on the pc board. The pin header is placed on the pc board by robotic equipment.

The receptacle housing is available for wire-to-wire application, and the plug housing is available for wire-to-wire and wire-to-board application. The 1-position receptacle housing and 1-position plug housing mate for wire-to-wire application only. The receptacle housing accepts the tab contacts, and the plug housing accepts the receptacle contacts. The plug housing features a locking latch that ensures positive mating of the connectors.

The contacts feature an orientation barrel that aligns with an orientation feature of the connector contact cavity to ensure proper orientation. The contact locking lances are designed to engage the connector contact retention shoulder and prevent the contact from backing out during mating of the connectors. The contacts are available in loose-piece for terminating with manual hand-held tools and strip form for terminating with semi-automatic or automatic electrically-powered machines.

2. REFERENCE MATERIAL

2.1. Revision Summary

Revisions to this application specification include:

- Modified CAUTION, and added Important and CAUTION to Paragraph 3.7

2.2. Customer Assistance

Reference Product Base Part Number 2106135 and Product Code L012 are representative of SlimSeal SSL connectors and contacts. Use of these numbers will identify the product line and help you to obtain product and tooling information. Such information can be obtained through a local Representative, by visiting our website at www.te.com, or by calling PRODUCT INFORMATION or the TOOLING ASSISTANCE CENTER at the numbers at the bottom of page 1.

2.3. Drawings

Customer Drawings for product part numbers are available from the service network. If there is a conflict between the information contained in the Customer Drawings and this specification or with any other technical documentation supplied, the Customer Drawings take priority.

2.4. Manuals

Manual 402-40 can be used as a guide to soldering. This manual provides information on various flux types and characteristics with the commercial designation, flux removal procedures, and a guide for information on soldering problems.

2.5. Instructional Material

Instruction Sheets (408-series) provide product assembly instructions or tooling setup and operation procedures and Customer Manuals (409-series) provide machine setup and operating procedures. Documents available that pertain to this product are:

- 408-3295 Preparing Reel of Contacts for Applicator Tooling
- 408-7424 Checking Terminal Crimp Height or Gaging Die Closure
- 408-8322 Heavy Duty Industrial (HD-I) Side-Feed Type Applicator
- 408-8053 Conversion Guide for Miniature Quick Change Applicators
- 408-8059 General Preventive Maintenance for Applicators
- 408-8547 CERTI-CRIMP* II Straight Action Hand Tools
- 408-9816 Handling of Reeled Products
- 409-5128 AMP-O-LECTRIC* Model "K" Terminating Machines 565435-5 (Obsolete)
- 409-5842 AMP-O-LECTRIC Model "G" Terminating Machines 354500-[]
- 409-5852 AMPOMATOR* CLS III-G Lead-Making Machines 122500-[] (Obsolete)
- 409-5866 AMPOMATOR CLS IV Lead-Making Machines 217500-[]

- 409-5878 AMPOMATOR CLS IV+ Lead-Making Machines 356500-[] (Obsolete)
- 409-10016 Entry Level Terminator (ELT) Machines 1338600-[]
- 409-10027 Stripping Modules 1490500 and 1490502
- 409-10029 Stripping Modules 1490501 and 1490503

2.6. Specifications

Product Specification 108-2391 provides expected product performance and test information.

3. REQUIREMENTS

3.1. Material

The pin headers and wire-to-board plug housings are made of flame-retardant thermoplastic. The wire-to-wire plug housings and receptacle housings are made of material having an F1 rating per UL 746C. The receptacle contacts and tab contacts are made of copper alloy.

3.2. Safety

Do not stack product shipping containers so high that the containers buckle or deform.

3.3. Storage

A. Shelf Life

The connectors and contact should remain in the shipping containers until ready for use to prevent deformation. The connectors and contacts should be used on a first in, first out basis to avoid storage contamination that could adversely affect performance.

B. Reeled Contacts

When using reeled contacts, store coil wound reels horizontally and traverse wound reels vertically.

3.4. Chemical Exposure

Do not store connectors or contacts near any chemical listed below as they may cause stress corrosion cracking.

- Alkalies
- Ammonia
- Citricates
- Phosphates
- Citricates
- Sulfur Compounds
- Amines
- Carbonates
- Nitrites
- Sulfur Nitrites
- Tartrates

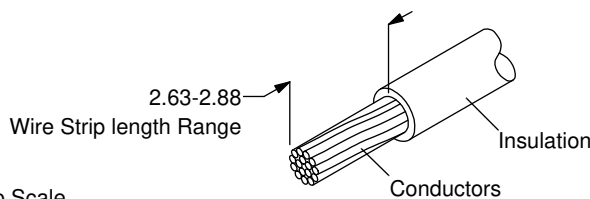
3.5. Wire Selection and Preparation

The contacts accept stranded wire sizes 24 through 18 AWG (UL Style 1007) with an insulation diameter range of 1.3 to 2.1. Proper strip length is necessary to properly insert the wire into the contact. The strip length of the wire is given in Figure 2.



CAUTION

Reasonable care must be taken not to nick, scrape, or cut any strands during the stripping operation.



Note: Not to Scale

STRANDED WIRE	
SIZE (AWG)	INSULATION DIAMETER RANGE
24-22	1.3-1.6
20-18	1.7-2.1

Figure 2

3.6. Contact Crimp Requirements

**NOTE**

Lubrication is required when crimping these contacts. It is recommended using Hydraulic Oil 22014 or Stoner Terminal Lubricant E807PT.

**CAUTION**

Wire insulation must NOT be cut or broken during the crimping operation. Reasonable care should be taken to prepare undamaged wire terminations.

The contact must be crimped to the wire according to instructions packaged with the application tooling.

A. Cutoff Tab and Burr

Cutoff tabs are the remaining portion of the carrier strip after the contact is cut from the strip. The following dimensional requirements will ensure proper application for these contacts. Refer to Figure 3.

- The cutoff tab must not extend beyond the insulation barrel more than the limit given.
- The burr resulting from the cutoff tab shearing must not exceed the dimension given.

B. Locking Lance

The locking lance must be free of damage.

C. Retention Feature

There must be no damage or distortion to the spring members of the receptacle contact or the tab end of the tab contact.

D. Conductor Location

The wire insulation and conductor must be visible within the transition area (between the contact insulation barrel and wire barrel). The insulation must not enter the wire barrel. The wire conductor ends must be flush with or extend slightly beyond the wire barrel to the limit provided in Figure 3.

E. Wire Barrel Crimp

The crimp applied to the wire barrel of the contact is the most compressed area and is most critical in ensuring optimum electrical and mechanical performance of the contact. The wire barrel must have the "F" crimp, where the tips of the wire barrel turn inward and capture the wire strands. The wire barrel crimp height and width must be within the dimensions provided in Figure 3.

F. Insulation Barrel Crimp

The insulation barrel crimp supports the wire insulation. The insulation barrel must be crimped so that the tips of the insulation barrel wrap around and capture the wire insulation. The insulation barrel crimp width is given in Figure 3.

G. Effective Crimp Length

Effective crimp length is defined as that portion of the wire barrel, excluding bellmouths, fully formed by the application tooling. For optimum crimp effectiveness, the crimp must be within the limits given in Figure 3.

H. Wire Barrel Seam

The seam between the two sides of the wire barrel must be completely closed and there must be no evidence of wire strands or loose wire strands visible in the seam.

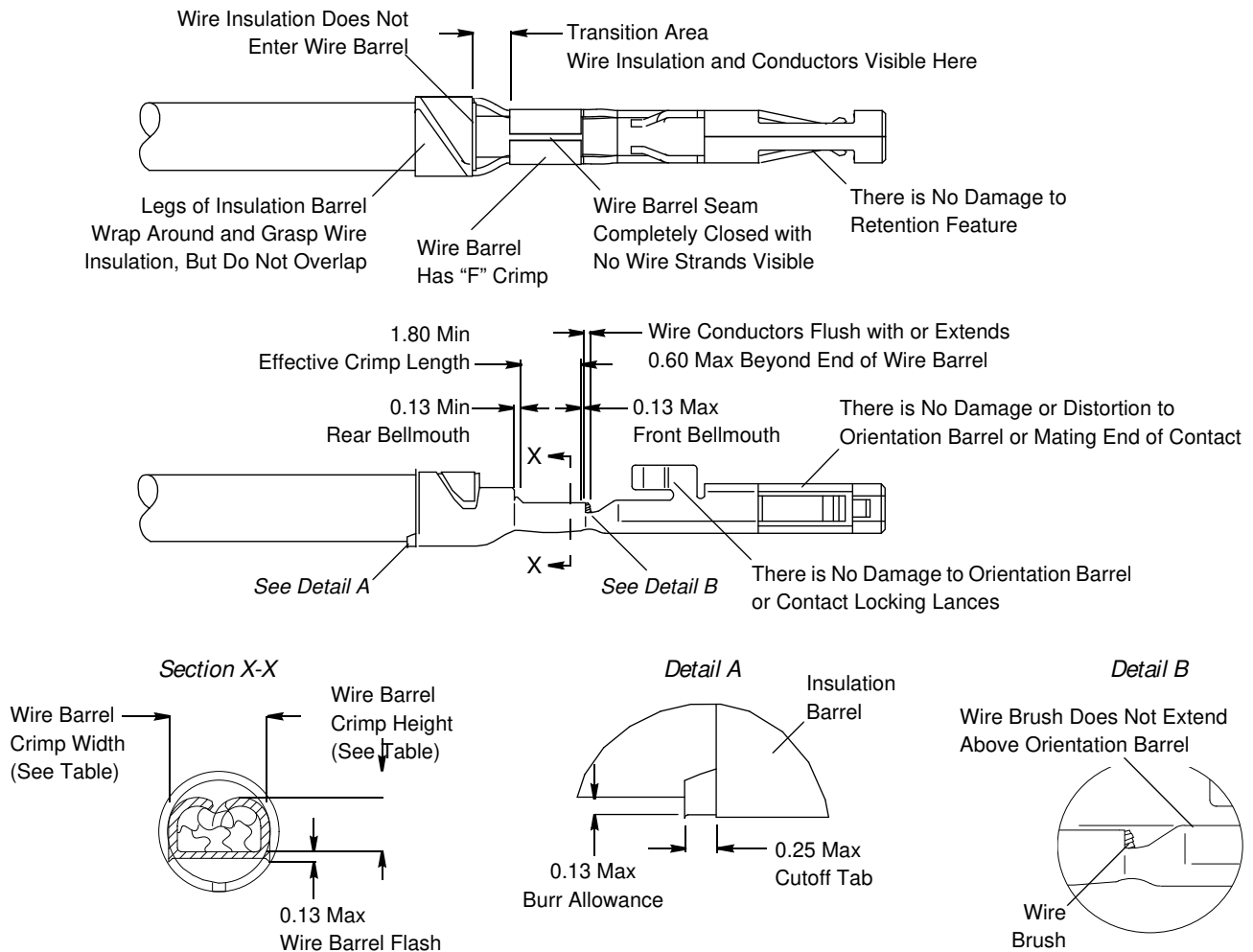
I. Insulation Barrel Seam

The two legs of the insulation barrel must completely grasp the wire insulation, but not overlap on top of one another.

J. Bellmouths

The front and rear bellmouths caused by extrusion of the contact material during crimping must be within the limits given in Figure 3.

Note: Receptacle contact shown; same requirements apply to the tab contact



Note: The developed crimp configurations result from using the specific tooling described in Section 5, TOOLING.

WIRE SIZE (AWG)	CONTACT							
	WIRE BARREL CRIMP				INSULATION BARREL CRIMP			
	HAND TOOL		APPLICATOR		HAND TOOL		APPLICATOR	
	HEIGHT ±0.05	WIDTH	HEIGHT ±0.05	WIDTH	HEIGHT (Ref)	WIDTH (Ref)	HEIGHT (Ref)	WIDTH (Ref)
24	0.79	1.07	0.74	1.07	1.50	1.80	1.69	1.57
22			0.79				1.82	
20	0.87	1.40	0.87	1.40	1.95	1.80	2.05	2.00
18	1.05		1.05		2.20		2.26	

Figure 3

K. Wire Barrel Flash

Wire barrel flash is the formation that may appear on both sides of the wire barrel as the result of crimping. It must not exceed the dimension provided in Figure 3.

L. Orientation Barrel

There must be no damage or distortion to the orientation barrel of the contact.

M. Straightness

The force applied during crimping may cause some bending between the wire barrel and the mating portion of the contact. Such deformation is acceptable within the following limits given in Figure 4.

— Up-and-Down

The crimped portion, including cutoff tab and burr, must not be bent beyond the limits given.

— Side-to-Side

The crimped portion must not be bent from one side to the other beyond the limits given.

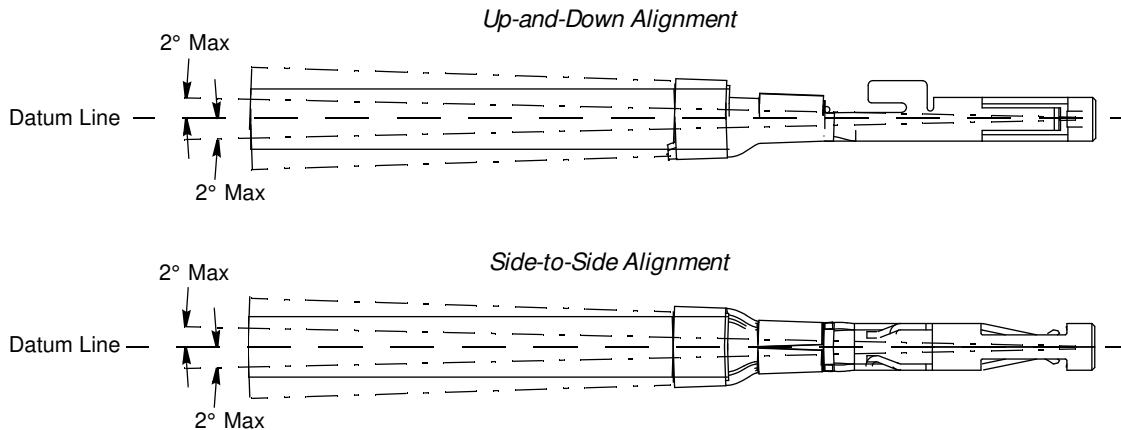


Figure 4

N. Twist and Roll

There should be no twist or roll of the wire barrel or mating portion of the crimped contact beyond the limits shown in Figure 5.

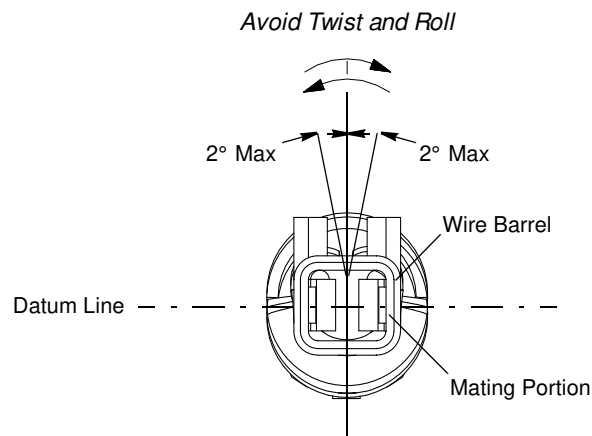


Figure 5

3.7. Contact Insertion

IMPORTANT: The interface seal must not be touched when handling the housing or during contact insertion.



CAUTION

Care must be taken to keep the interface seals clean and protected from damage. The interface seal must not be touched or contact equipment or packaging material, such as cardboard or paper; otherwise, the necessary surface lubricant will wipe off of the interface seal. A damaged or dry interface seal will cause the connector to not function properly.

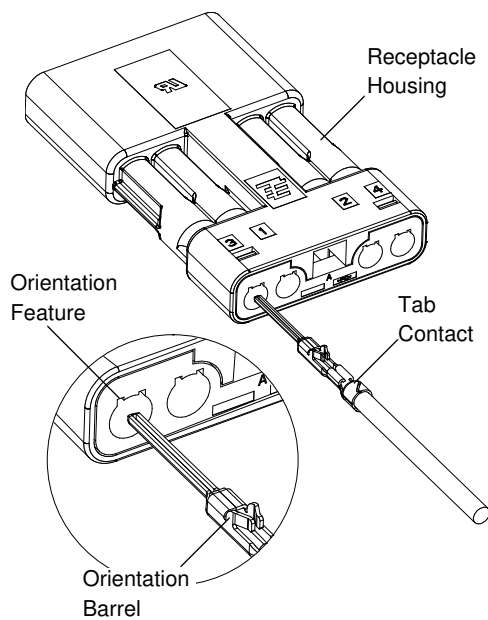
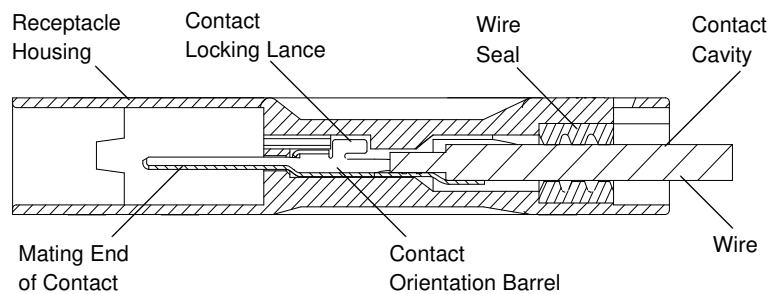
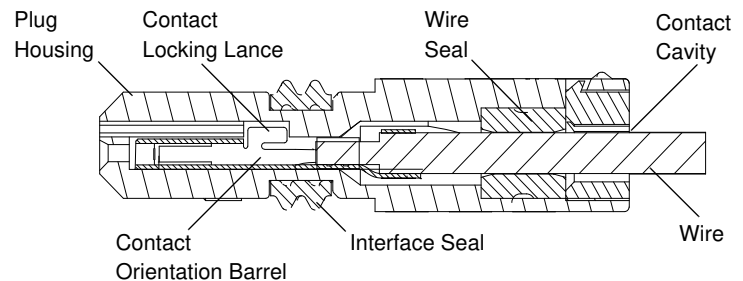

CAUTION

Tab contacts are for use with receptacle housings only. Tab contacts must not be inserted into plug housings. Receptacle contacts are for use with plug housings only. Receptacle contacts must not be inserted into receptacle housings. Contacts should not be extracted from the housing. Extraction may damage the contact, wire seal, or housing.

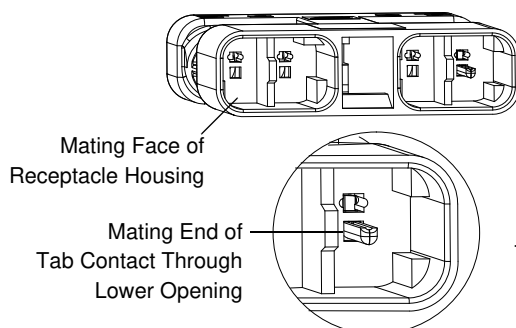
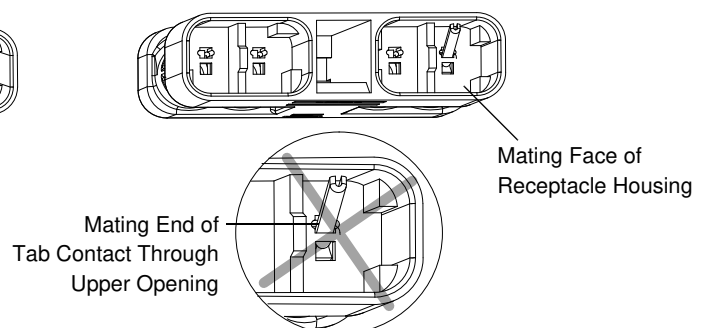
The contact orientation barrel must be aligned with the contact cavity orientation feature located at the back (mating face) of the plug housing or receptacle housing. The contact should be properly oriented before attempting to insert it into the contact cavity of the housing. In order to prevent damage to the wire seal, the contact must be inserted slowly and straight (not turned) as it passes through the seal and into the housing. When the contact is fully inserted, the contact locking lances will engage the housing contact retention shoulder. After insertion, the wire should be pulled back lightly to ensure that the contact is fully seated. Refer to Figure 6.


NOTE

An insertion tool is not required to insert contacts into the plug housing or receptacle housing.

Contact Installation
Aligning Tab Contact with Receptacle Housing

Tab Contact Fully Inserted into Receptacle Housing

Receptacle Contact Fully Inserted into Plug Housing


IMPORTANT: Interface seal must not be touched when handling housing or during contact insertion.

Correct Installation of Tab Contact

Incorrect Installation of Tab Contact

Figure 6

3.8. PC Board

A. Material and Thickness

The pc board material shall be glass epoxy (FR-4 or G-10). The pc board thickness shall be 1.57.



NOTE

For suitability of other board materials and thicknesses, contact *PRODUCT INFORMATION* at the number at the bottom of page 1.

B. Tolerance

Maximum allowable bow of the pc board shall be 0.03 over the length of the pin header.

C. Holes for Through Hole Mount Connectors

The pc board holes for the contact solder tines and boardlocks must be drilled and plated through to specific dimensions to prevent stubbing during placement of the pin header on the pc board and to ensure optimum continuity for circuits after soldering. The drilled hole size, plating type, and plating thickness will depend on the application requirements. The finished hole size must be as stated to provide unrestricted insertion and ensure adequate application of solder to the solder tines. See Figure 7.

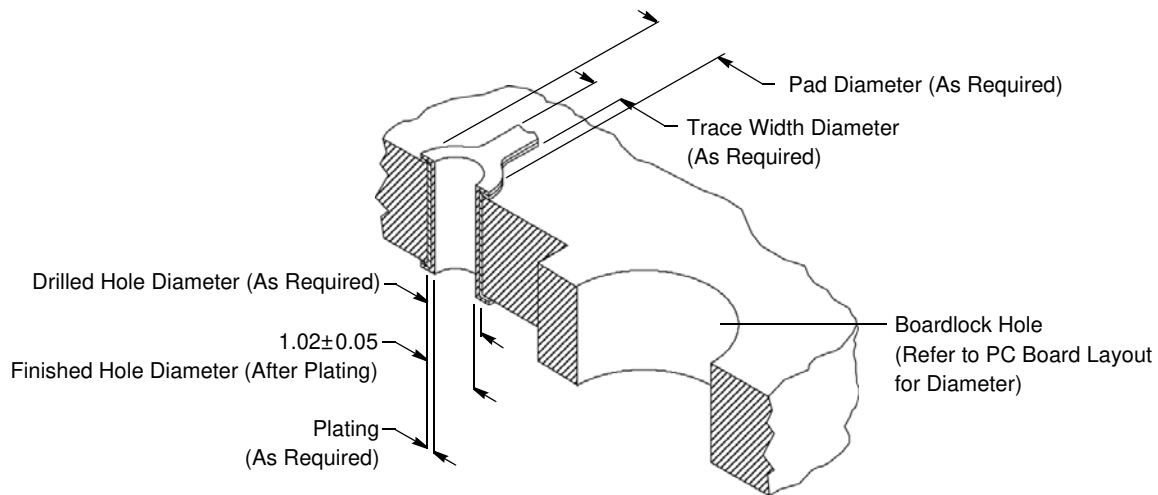


Figure 7

D. Pads for Surface Mount Connectors

The pc board pads must be solderable in accordance with Electronic Industries Alliance (EIA)-638, "Surface Mount Solderability Test."

E. Layout

The distance between mating connectors must be considered when determining location of pin headers to ensure full mating with mating connectors (refer to Paragraph 3.12).

For the through hole mount pin header, the pc board and lead wires must be solderable in accordance with Joint Industry Standard IPC/EIA J-STD-003, "Solderability Tests for Printed Boards." The pc board holes must be precisely located to ensure proper placement and optimum performance of the through hole mount pin header. The pc board must be designed using the dimensions provided in Figure 8.

Representative samples of recommended pc board pattern, dimensions, and tolerances are shown in Figure 8.



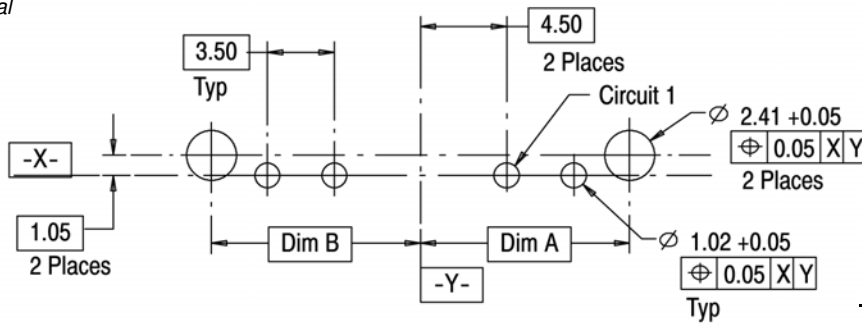
NOTE

Consult the specific pin header customer drawing for the appropriate pc board layout.

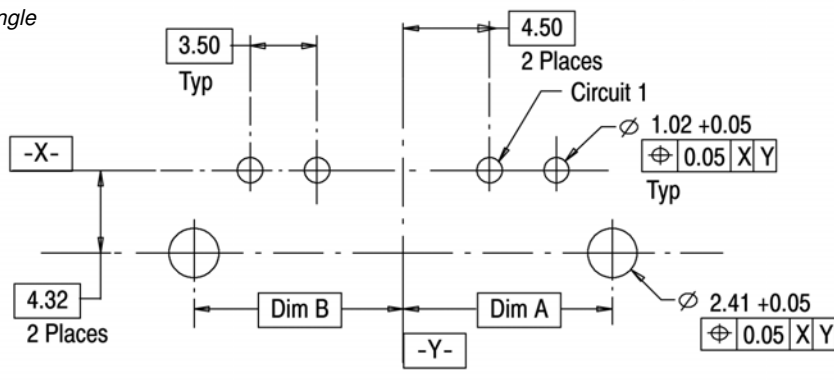
Recommended Sample PC Board Layouts
Component Side Shown

Through Hole Mount Pin Headers

Vertical



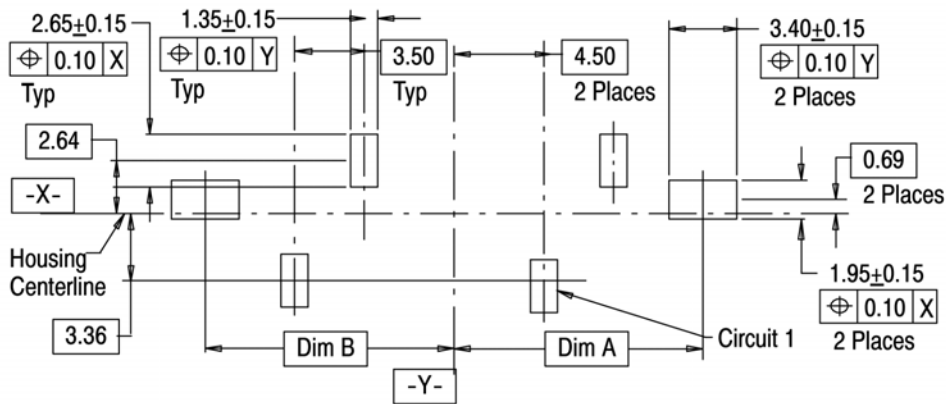
Right-Angle



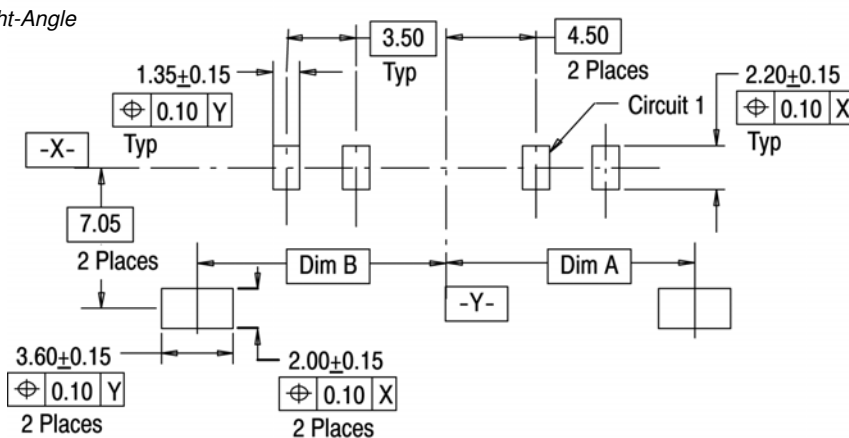
THROUGH-HOLE MOUNT PIN HEADER POSITION	DIMENSION	
	A	B
2	7.42	7.42
3	7.42	10.92
4	10.92	10.92

Surface Mount Pin Headers

Vertical



Right-Angle



SURFACE MOUNT PIN HEADER POSITION	DIMENSION	
	A	B
2	8.96	8.96
3	8.96	12.46
4	12.46	12.46

Figure 8

3.9. Pin Header Placement

Automatic machine placement of pin headers is recommended due to the inherent difficulty of manual placement of fine-pitch pin headers and to minimize possible damage that could result from improper handling. The vertical pin header should be picked up by the vacuum pick-up pad, and the right-angle pin header can be picked up by the housing. If the pin headers are placed on the board manually, the pin header should be handled only by the housing to avoid deformation, contamination, or damage to the contact solder tines and boardlocks or hold-downs.



CAUTION

To avoid damage to the pin header, for machine placement, the pin header should be picked up by the machine directly from the pin header embossed-tape package.

A. Through Hole Mount Pin Header

When placing through hole mount pin headers on the pc board, the contact solder tines must align and start into the matching holes before seating the pin header onto the pc board.

B. Surface Mount Pin Header

Optimally, the contact solder tines should be centered on the pc board circuit pads. However, slight misalignment is permissible as shown in Figure 9.

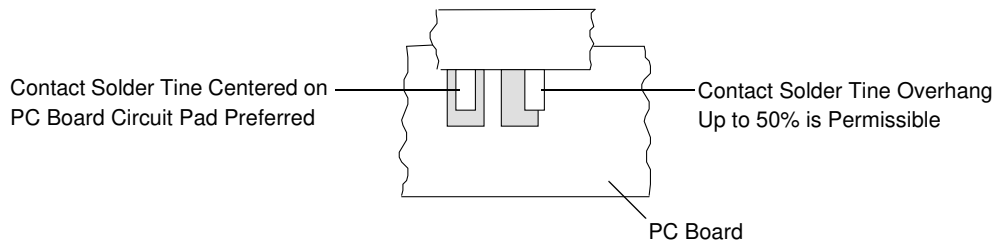


Figure 9

3.10. Soldering

After the pin header is seated onto the pc board, the boardlocks or hold-downs must be soldered along with the contacts during the soldering process. Guidelines and procedures must be observed when soldering contacts. All contacts must be soldered, cleaned, and dried according to the following:

A. Solder Paste Characteristics

1. Alloy type shall be SAC 305; Sn 96.5/Ag 3.0/Cu 0.5.
2. Flux incorporated in the paste shall be rosin, mildly active (RMA) type.
3. Paste will be at least 80% solids by volume.
4. Mesh designation -200 to +325 (74 to 44 square micron openings, respectively).
5. Minimum viscosity of screen print must be 5×10^4 cp (centipoise).
6. Minimum viscosity of stencil print must be 7.5×10^4 cp (centipoise).

B. Solder Volume

Recommended solder volume deposit (wet paste per solder pad) must be:

- 1.59 mm³ per contact solder tine
- 1.08 mm³ per boardlock or hold-down



NOTE

Solder volume may vary depending on solder paste composition. Values provided are based on 90% solids by volume.

C. Process

The pin headers can be soldered using wave, non-focused infrared (IR) reflow soldering, or equivalent soldering technique. The temperatures and exposure time must be as specified in Figure 10.

SOLDERING PROCESS	WAVE TEMPERATURE (Max)	TIME (At Max Temperature)
Wave	260°C [500°F]	5 Seconds
IR	225°C [437°F]	90 Seconds

Figure 10

D. Flux Selection

Contact solder tines must be fluxed prior to soldering with a mildly active, rosin base flux. Selection of the flux will depend on the type of pc board and other components mounted on the pc board. Additionally, the flux must be compatible with the wave solder line, manufacturing, health, and safety requirements. Call PRODUCT INFORMATION at the number at the bottom of page 1 for consideration of other types of flux.

E. Stencil or Screen

The stencil aperture is determined by the size of the circuit pad and thickness of the stencil. It may be any shape as long as it prevents solder bridging and maintains the correct volume of solder paste.



CAUTION

All traces must be covered by solder mask in the solder deposit area. Exposed traces could cause bridging and create a short, or wick solder away, producing a weak solder joint.



CAUTION

If a hold-down aperture is used, the design must ensure that the pin header housing will not sit on the solder deposit.

F. Solder Mask

Solder mask is recommended between all pads. If a trace is run between adjacent pads on the solder side of the pc board, a solder mask must be applied over the trace to prevent bridging and wicking of solder away from the contact solder tines. Additionally, there should be solder mask covering any traces in the area of the boardlocks or hold-downs (if applicable) solder deposit. Liquid photo imageable or dry film solder masks are recommended.

G. Cleaning

After soldering, removal of fluxes, residues, and activators is necessary. Consult with the supplier of the solder and flux for recommended cleaning solvents. Cleaners must be free of dissolved flux and other contaminants.



CAUTION

Even when using "no clean" solder paste, it is imperative that the contact interface be kept clean of flux and residue, since it acts as an insulator. Flux may migrate under certain conditions with elevated temperatures and; therefore, cleaning is necessary.



DANGER

Consideration must be given to toxicity and other safety requirements recommended by the solvent manufacturer. Refer to the manufacturer's Material Safety Data Sheet (MSDS) for characteristics and handling of cleaners. It is not recommended using Trichloroethylene and Methylene Chloride because of harmful occupational and environmental effects. Both are carcinogenic (cancer-causing).

H. Drying

When drying cleaned assemblies, make certain that temperature limitations are not exceeded: -40 to 105°C [-40 to 221°F]. Excessive temperatures may cause housing degradation or plating deterioration.

3.11. Checking Installed Pin Header

All solder joints should conform to the requirements specified in this document and those specified in Workmanship Specification 101-21 for surface mount pin headers and Joint Industry Standard IPC/EIA J-STD-001, "Requirements for Soldered Electrical and Electronic Assemblies," for through hole mount pin headers. The solder must be evenly distributed and not cracked.

The pin header standoffs must be seated on the pc board not exceeding the dimension given in Figure 11.

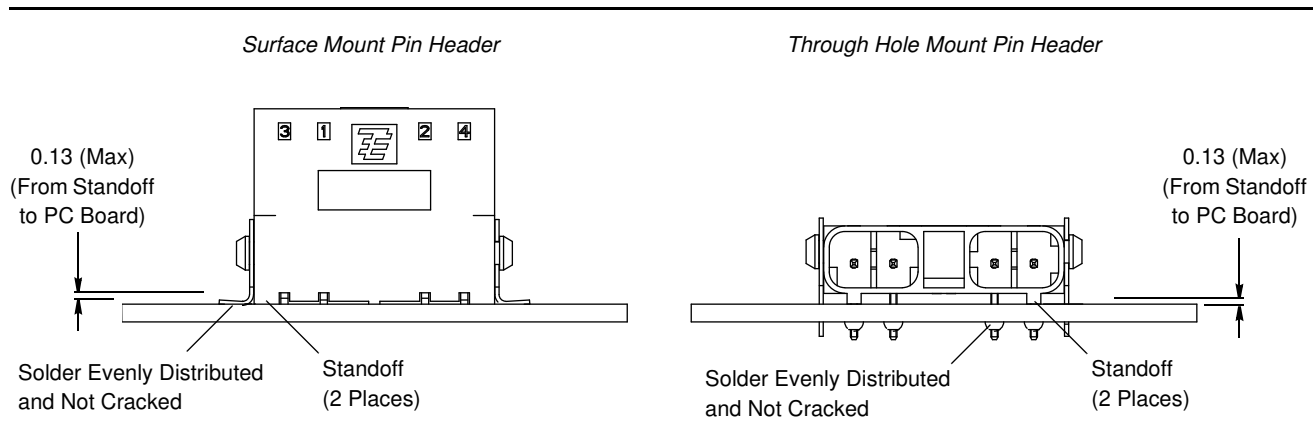


Figure 11

3.12. Mating Connectors

The plug housing has an integral locking latch that should be fully seated and latched to the pin header locking ledge after mating. The locking latch and locking ledge ensure positive mating of connectors.



CAUTION

Connectors should be handled only by the housing to avoid deformation, contamination, or damage to the contact solder tines. Pc board mounted connectors must be fully supported during mating to prevent damage from the mating force with the mating connector.



NOTE

Plug housings will mate only with the appropriate pin headers or receptacle housings; the plug housing and pin header or receptacle housing must have identical number of circuit positions and rows.

A. Polarization

The design of each contact cavity assures polarization for mating connectors.

B. Mating Dimension

The distance between mating connectors must be considered when determining location of connectors to ensure full mating. Mating dimensions are provided in Figure 12.

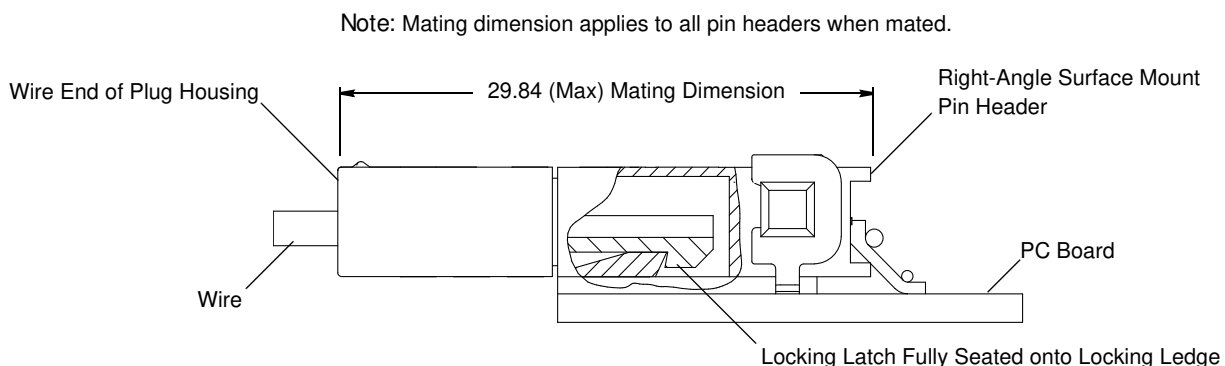


Figure 12

3.13. Unmating

Connectors must be unmated by releasing the locking latch of the plug housing from the locking ledge of the pin header or receptacle housing, and pulling the plug housing straight away from the mating connector.



CAUTION

To avoid damage to the 1-position plug housing, the locking latch must not be lifted more than 5 mm when unmating the connectors.

3.14. Sealing

The plug housing and receptacle housing wire entry and interface are sealed by integral seals in accordance with IP67.

The pc board side of the pin header must be potted for sealing.

Seals (2- and 3-position) may be applied to the receptacle housing mating face and pin header mating face when unmated to prevent environmental exposure or damage. For the receptacle housing, a seal can be installed before or after contacts are installed. The seal should be aligned with the mating face and inserted as shown in Figure 13.

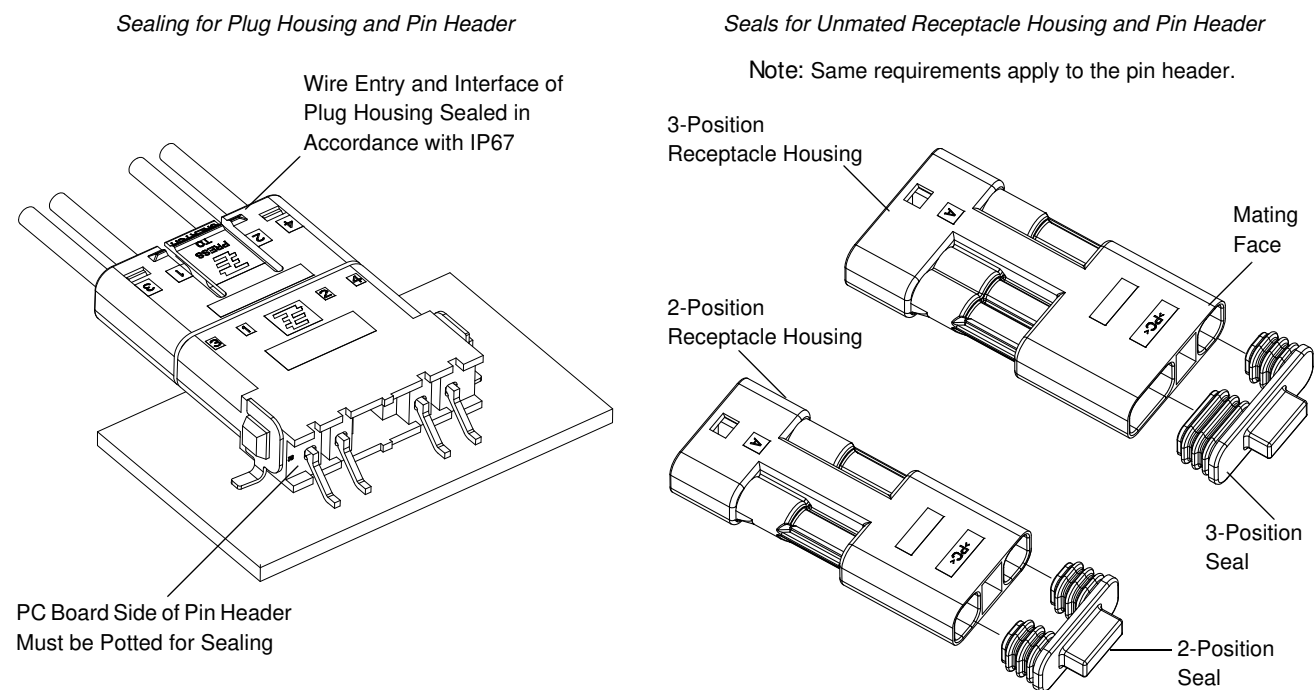


Figure 13

3.15. Replacement and Repair

Defective or damaged connectors must be replaced. Pin headers require standard de-soldering of all contact solder tines for removal from the pc board. Individual contacts cannot be replaced. Pin headers must not be used after removal from the pc board.

A defective or damaged contact can be replaced before insertion into the housing by cutting it from the wire. Contacts should not be replaced after insertion into the housing. Extraction may damage the contact, wire seal, or housing.

4. QUALIFICATION

SlimSeal SSL connectors and contacts are Recognized by Underwriters Laboratories Inc.(UL) to UL 1977 and CSA C22.2 No. 182.3.

5. TOOLING

Tooling part numbers and instructional material packaged with the tooling are given in Figure 14.

5.1. Hand Crimping Tool

The hand crimping tools accommodate the full wire size range for terminating crimp-type contacts. These tools are designed for prototype and low-volume application of loose-piece contacts.

5.2. Robotic Equipment

For automatic machine placement of surface mount pin headers, a pc board support must be used to prevent bowing of the pc board during the placement of the pin header on the pc board. It should have flat surfaces with holes or channel large enough and deep enough to receive the contacts and boardlocks or hold-downs.

Robotic equipment must have a true position accuracy tolerance to properly locate the contacts. This includes gripper and fixture tolerances as well as equipment repeatability. It must use the contact datum surfaces detailed on the customer drawing to ensure reliable placement.

5.3. Applicator

The applicators are designed to crimp strip-form contacts onto pre-stripped wire, and provide for high volume, heavy duty production requirements. These applicators accept interchangeable crimping dies and must be installed onto an automatic power unit.

5.4. Power Unit



NOTE

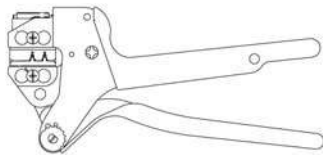
Modified designs and additional tooling concepts may be available to meet other application requirements. Machines have been designed for a variety of application requirements. For assistance in setting up prototype and production line equipment, call the TOOLING ASSISTANCE CENTER at the number at the bottom of page 1.

A. Semi-Automatic Machine

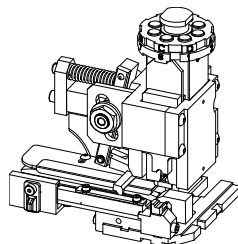
The semi-automatic machine is an electrical power unit designed for terminating pre-stripped wires onto reel-fed contacts. It is designed to be bench mounted and used for high volume applications.

B. Automatic Machine

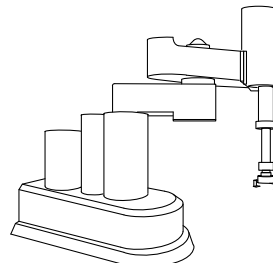
The automatic machine is an electrical power unit that provides the force required to drive an applicator for crimping tape-mounted contacts. It can be set up to automatically measure, cut, strip, and terminate wire. It is designed to be floor standing and provides for high volume, heavy duty production requirements.



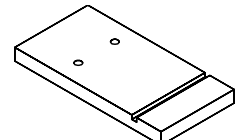
CERTI-CRIMP II Straight Action Hand Tool (See Table) (408-8547)



HD-I Side-Feed Type Applicator (See Table) (408-8322)



Robotic Equipment

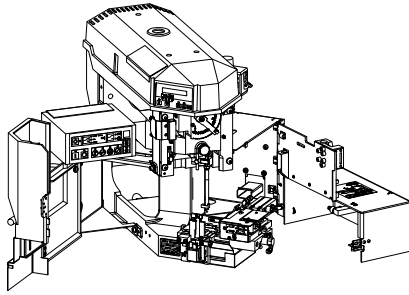


PC Board Support Fixture

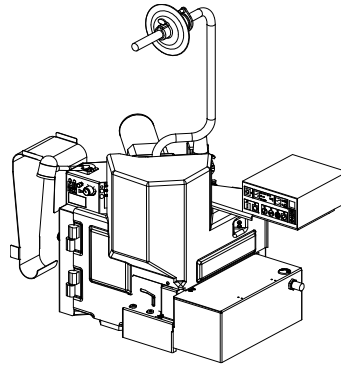
WIRE SIZE RANGE (AWG)	HAND TOOL	APPLICATOR †
24-22	2063956-1	1530178-[]
20-18	2063957-1	1530177-[]

† Refer to Applicator Customer Drawing for applicable dash number.

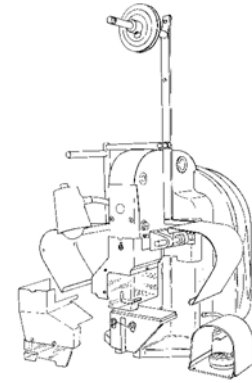
Figure 14 (Cont'd)



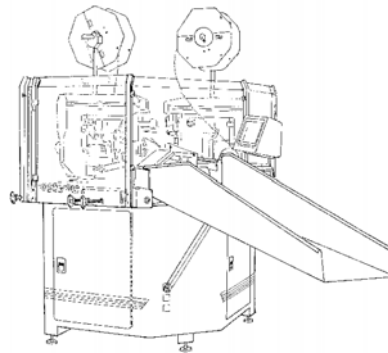
AMP-O-LECTRIC Model "G" Terminating
Machines 354500-[] (409-5842)
with Optional Stripping Module
1490500 or 1490502 (409-10027)
1490501 or 1490503 (409-10029)



ELT Machines 1338600-[]
(409-10016)
with Optional Stripping Module
1490500 or 1490502 (409-10027)
1490501 or 1490503 (409-10029)



AMP-O-LECTRIC Model "K"
Terminator Machine 565435-5
(409-5128) (Obsolete)



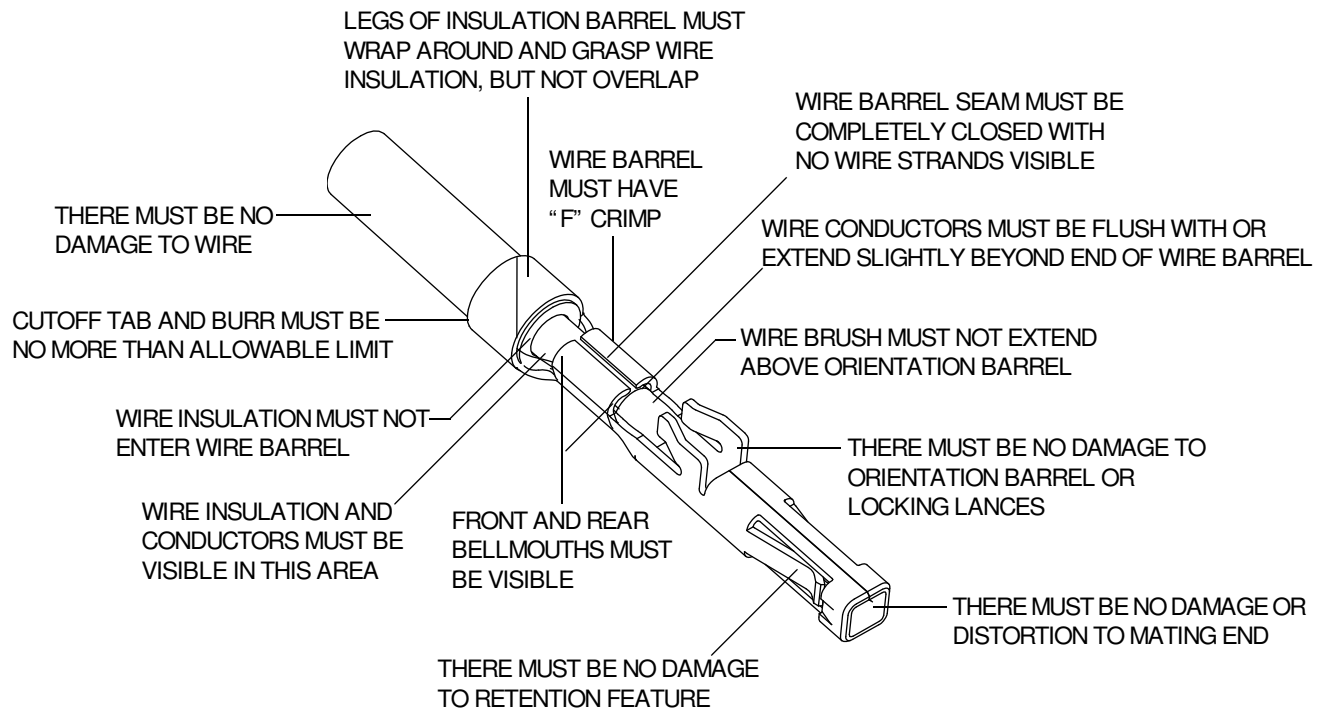
AMPOMATOR CLS IV Lead-Making Machines
217500-[] (409-5866)
AMPOMATOR CLS III-G Lead-Making Machines
122500-[] (409-5852) (Obsolete)
AMPOMATOR CLS IV+ Lead-Making Machines
356500-[] (409-5878) (Obsolete)

Figure 14 (End)

6. VISUAL AID

The illustration below shows a typical application of SlimSeal SSL connectors and contacts. This illustration should be used by production personnel to ensure a correctly applied product. Applications which DO NOT appear correct should be inspected using the information in the preceding pages of this specification and in the instructional material shipped with the product or tooling.

NOTE: Receptacle contact shown; same requirements apply to tab contact.



NOTE: Surface mount pin header and receptacle housing shown; same requirements apply to through hole pin header and other mating connectors unless otherwise noted.

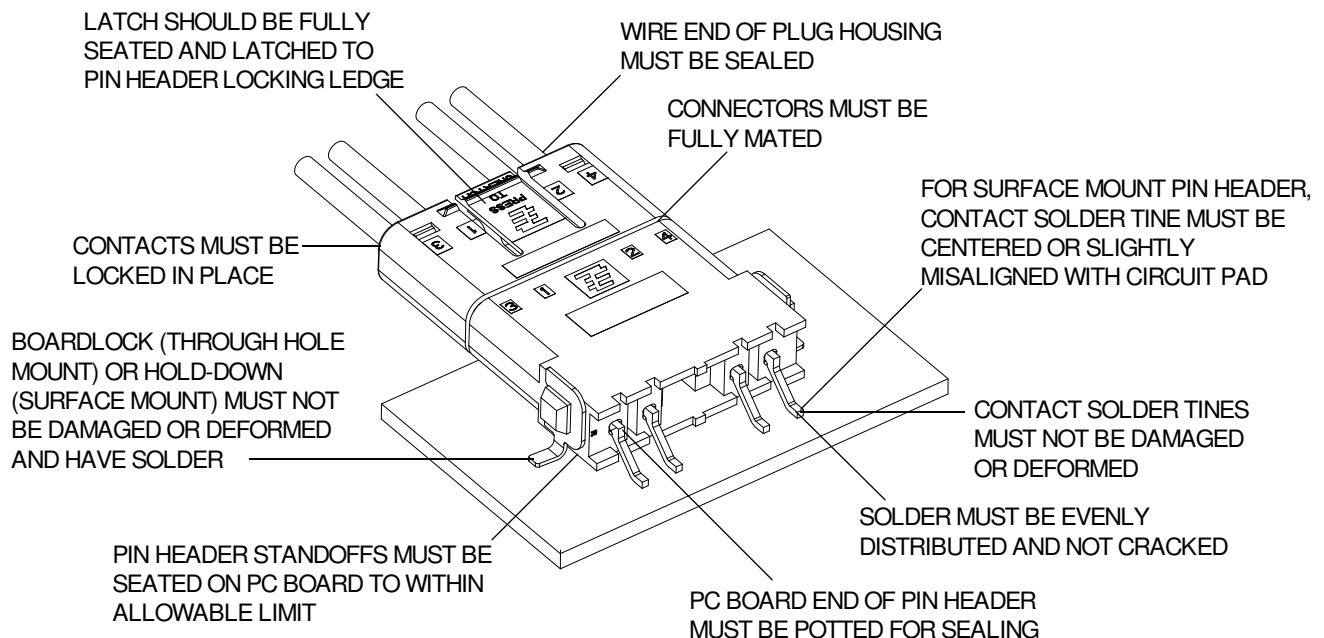


FIGURE 15. VISUAL AID