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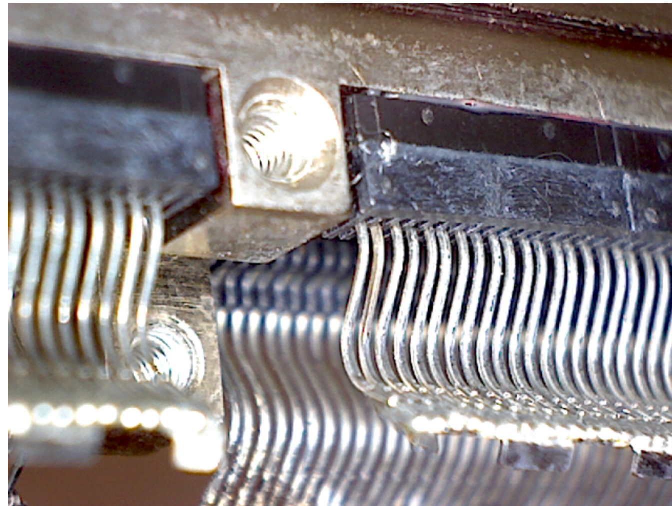
# HOTBAR REFLOW SOLDERING



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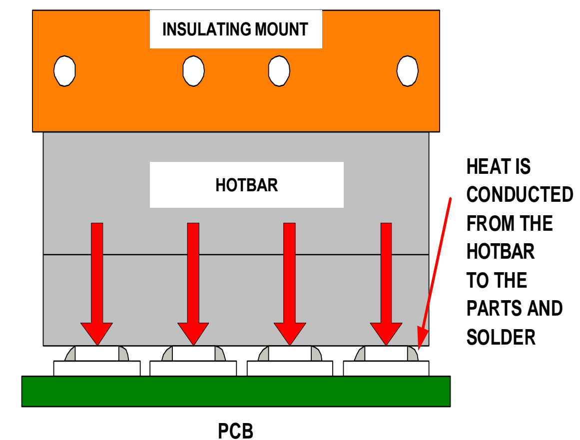
# What is Hotbar Reflow Soldering?

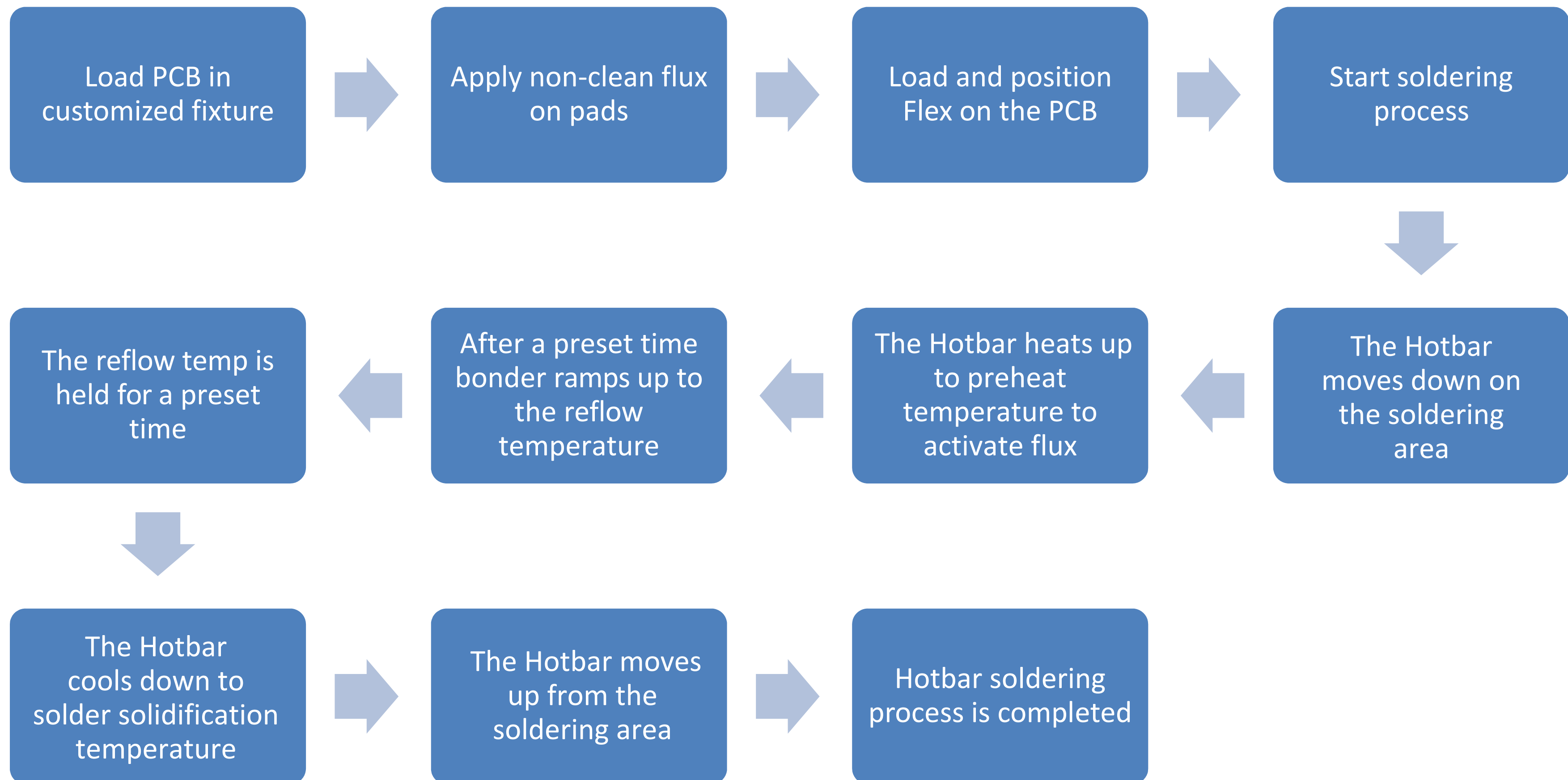
Pulsed Heat Thermode (Hotbar) soldering, is a joining technology where two pre-tinned parts are heated to the melting point of the tin. The joining technology results in a permanent electro-mechanical junction




The required process temperature is supplied by a thermode, also know as a Hotbar. This Hotbar is pressed on the upper part to transfer the thermal energy to both parts.

Closed loop process control is used to control the time-temperature profile .

# How does it work?



# The benefits of Hotbar Reflow Soldering

- Suitable for mass production
- Reliable processing, always equal process conditions
- Cost effective due to the fact that no third connector is needed to connect flex/wire to the PCB/substrate
- Multiple connections to be made simultaneously. The number of leads depends on product, pitch, design.
- Fast temperature ramp-up and cool-down
- Closed loop temperature and process control.
- Extremely accurate part positioning

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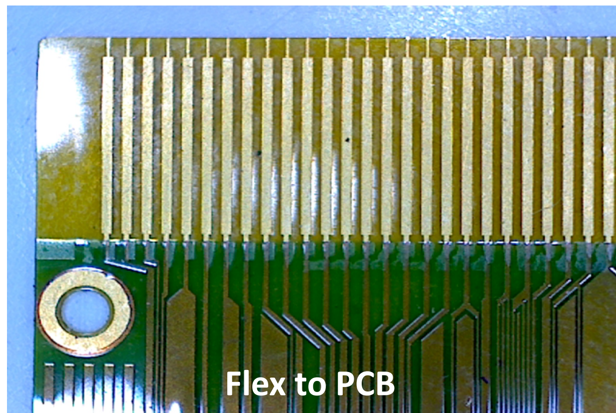
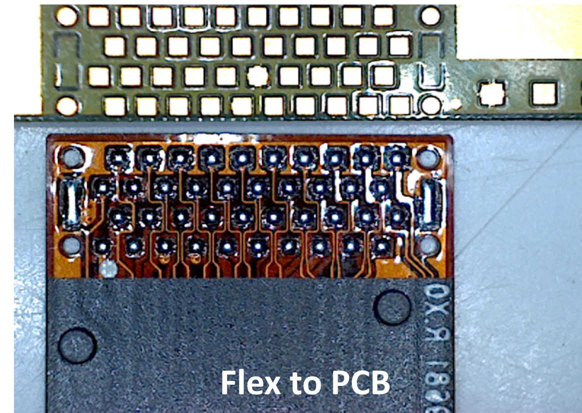
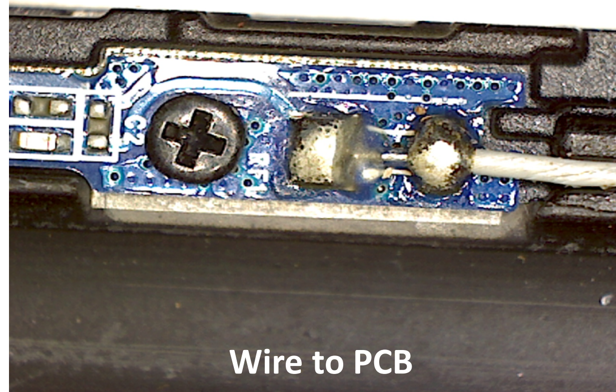
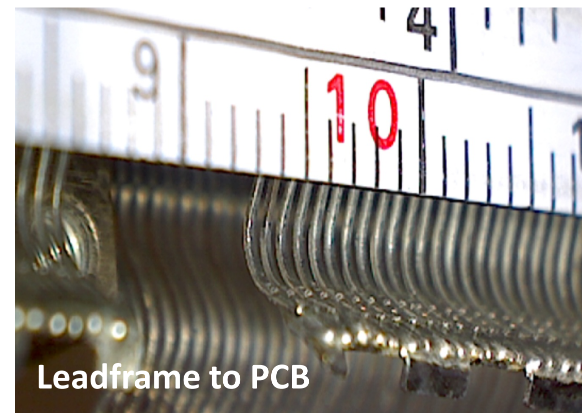
# Hotbar Reflow Soldering Applications



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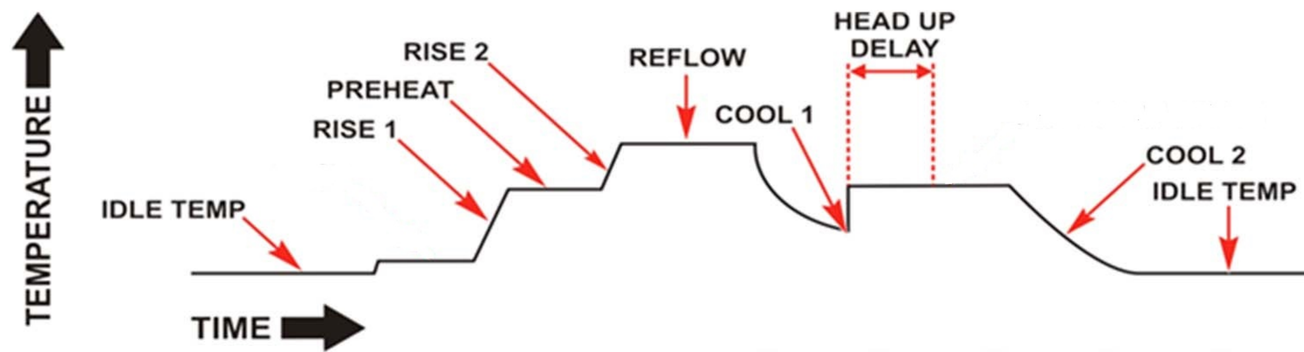
# Process Description: Preparation

In preparation for a Hotbar Reflow soldering process, the following steps need to be taken:

1. The base substrate is located in a fixture, and flux is applied to the pads.
2. The flex is positioned in the parts fixture, ensuring alignment of both sets of pads.
3. A process start signal is given to the temperature controller

More info about the parts, the fixtures and the fluxing can be found further in this article. The Hotbar Reflow Soldering process itself consists of the following process steps: heating up, reflow and cooling down. These process steps are described in the next sheets.



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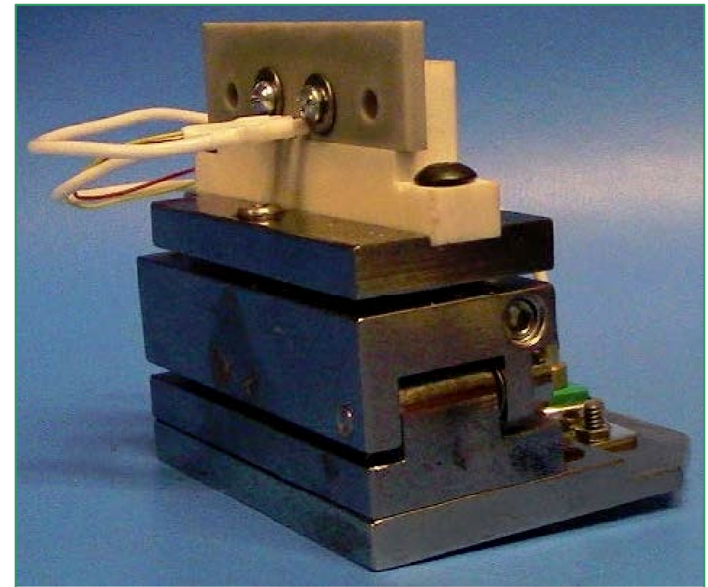
# Process Description: Contacting

The thermode or Hotbar is mounted to a force actuator by means of a quick connect block. The force actuator has an accurate and stable linear guidance for the hotbar. Movement is done with a pneumatic cylinder or an electrical motor. Closed loop force control is prefered for accurate force. Most reflow joints of this nature require fewer than 100 Newton pressure. Force should be calibrated and set to the correct level to achieve the right transfer of thermal energy to the solder joint. The force actuator should have accurate coplanarity adjustment to set the flatness of the hotbar to the product accurately.



After the start signal is given, the hotbar is gently lowered until it seats on the product. Force is increeased until the preset force is reached. When the right force is reached, a signal is passed to the power supply, which starts heating up the Hotbar to reflow temperatures.

# Process Description: Heating up

The Hotbar holds down the product with the preset force. The Hotbar is at “room temperature” or a "idle temperature". The temperature controller, also referred to as the "TC", now receives the start signal for the soldering process.

The TC sends current through the Hotbar. The Hotbar is designed so that the electrical resistance is highest at the footprint (where it touches the product). Heat is generated because of the combination of current and electrical resistance. A small thermocouple is embedded in the hotbar. This thermocouple feeds back the actual Hotbar temperature to the TC. This allows for closed-loop control during the temperature-time cycle.

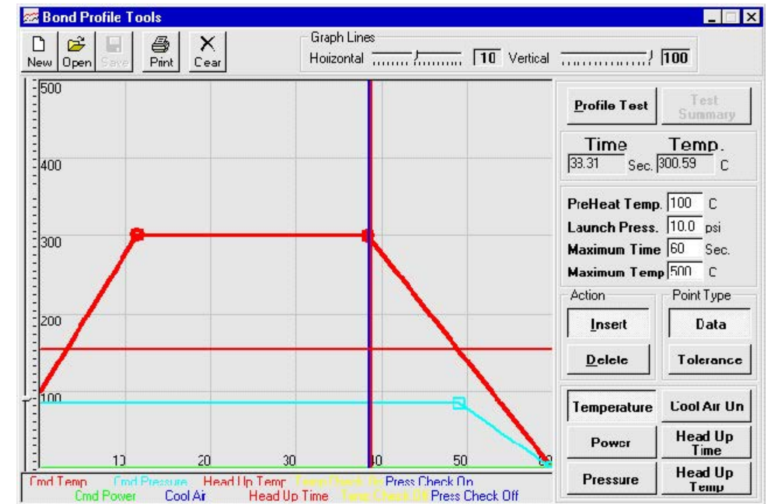
Normal rise time for most TODDCO's Ceramic Hotbars is 1.5 to 2 seconds, equaling a heating rate of about 200°C per second. TODDCOs TC controls the temperature all the way through the heating phases. When the “REFLOW temperature” is nearly reached the TC needs to slow down the heating rate to prevent a temperature overshoot. A TODDCO TC and Hotbar combination will compensate for all differences in heat-loads that can occur during normal production circumstances.

# Process Description: Reflow

During the reflow period the flux is activated, the flux cleans the surfaces and the solder is heated until it starts melting on all pads. This normally takes 3-8 seconds, at Hotbar temperatures around 325°C (Hotbar touches the leads), 400°C (Hotbar touches kapton) or 500°C (ceramics and MC-PCB soldering). Although normal solder will melt at 180°C, ideal solder temperature is above 220°C to get a good flowing and wetting behavior but below 280°C to prevent overheating the solder. The Hotbar must be set higher due to the thermal transfer losses. With TODDCO's TC, time can be programmed in 0.1-sec. increments and temperature in one-degree increments. Use the minimum time and temperature to achieve the desired joint and minimize the parts exposure to heat/damage.

# Process Description: Cooling

When the solder is connected on all pads, the energy delivery to the Hotbar can be stopped. The Hotbar need to start cooling down. The cooling process can be shortened by the use of forced air-cooling. The TC switches a relay that controls the flow of air at the end of the reflow period and  cools the joint and Hotbar. For optimum process control, cooling is done to a specific temperature. This temperature is set below the solder solidification temperature. Therefore, as soon as the solder becomes solid, the process is ended and a joint is formed. Because most connections have a relatively high heat sink, the temperature in the solder is always lower than the measured Hotbar temperature, even with forced air-cooling. Therefore, the release temperature can be set to 170ºC in most cases without the chance of releasing the parts before solidification has taken place.



# Process Description: Quality Control

**Quality control <u>before</u> starting the process is done by:**

➢TODDCO can provide a force measurement kit, which contains a precision load-cell and a control panel with readout display.

➢ The TODDCO pressure sensitive paper, especially designed to optimize the planarity of the Hotbar in combination with the product. Putting it in between the hotbar and the product support will result in an accurate readout of planarity.

➢Knowing and understanding the temperature during all the different Hotbar processes inside the materials is essential for optimal results. An easy-to-use handheld temperature meter can be used in combination with ultra flat thermocouples to check temperature. The thermocouple can be sandwiched between the parts, and the actual process temperature can be measured inside the connection. The thermocouple is re-usable.

**Quality control during the entire process cycle**

The TODDCO Bonder Control Software combines TODDCO Hotbar expertise with TODDCO process experience all in one unit. The general series bonders measure force, temperature, and time, allowing for continuous control throughout the **<u>entire process cycle</u>**.

**Quality control after the bonding cycle**

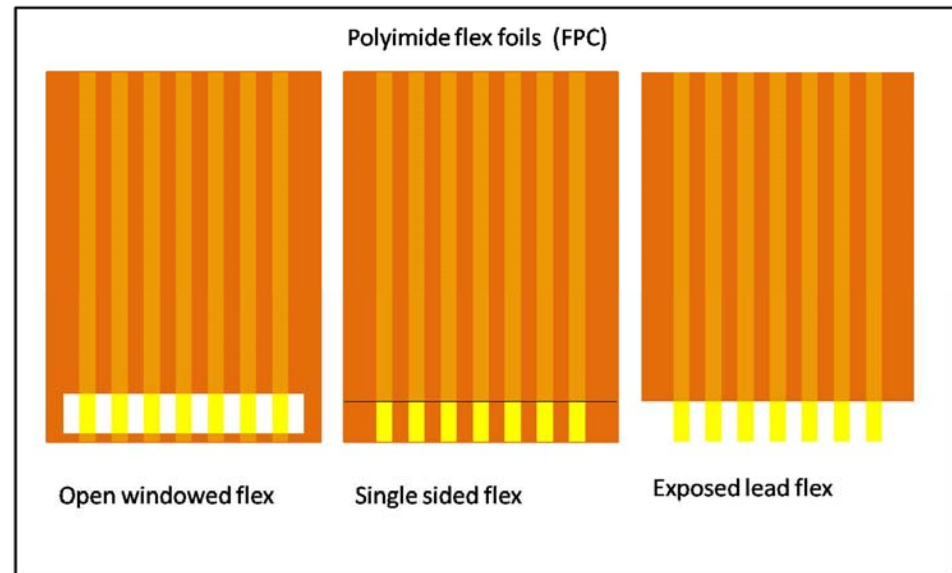
Using the TODDCO Bonder Control Software for Hotbar Reflow Soldering, process data logs can be saved and exported to USB for variance analysis

# Flex Design: Connection Type

**Open windowed flex design:**

This design has both sides of the polyimide material removed from the joint area but has support from the remaining polyimide material on the sides and also along the end of the traces. This design gives some strength to the assembly and is resilient to harsher handling.

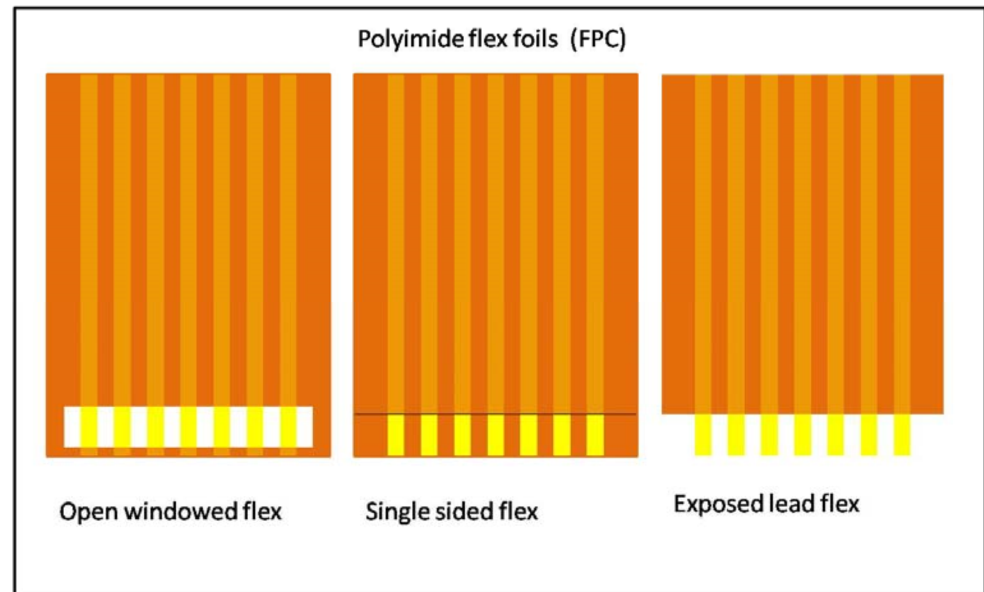
As the traces are exposed, the thermal transfer to the parts is good and excess solder has extra space to flow. Thermode sizing is critical as it must fit into the window and allow space for the molten solder to flow. This design behaves similar to the exposed lead design.



# Flex Design: Connection Type

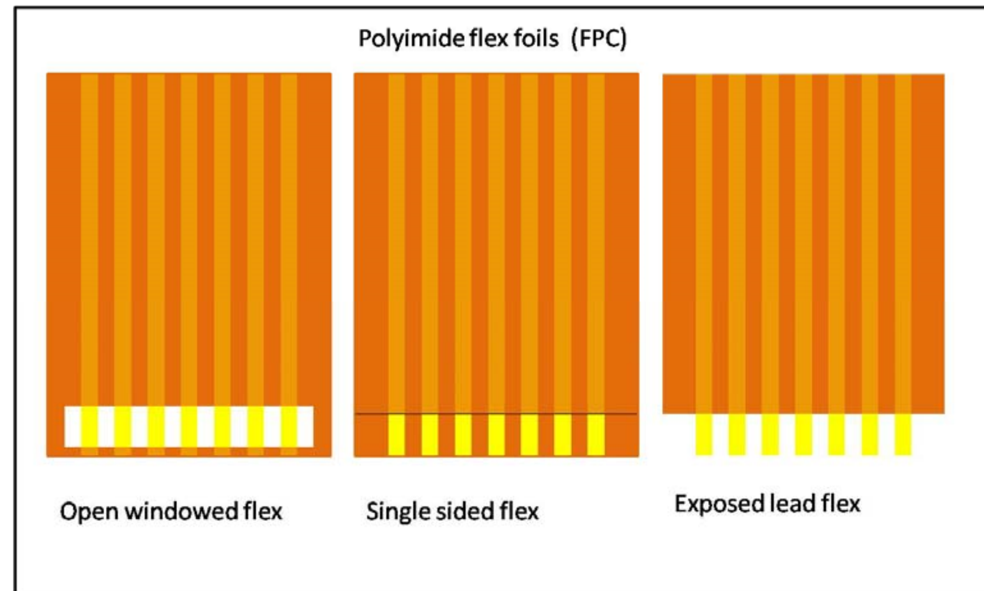
**Single sided flex design:**

This design has the polyimide removed on one side only. Heat is conducted from the Hotbar through the solid polyimide surface to the exposed traces underneath. The polyimide conducts heat through the insulation to the exposed traces and pads on the PCB. The polyimide thickness in the joint area is limited to about 50 microns, to enable conduction. If the polyimide has to be heated past 400 - 425°C, burning of polyimide and Hotbar contamination can occur. This design is less tolerant of excess solder on the PCB pads because there is little room for the excess solder to flow. The single-sided flex is the best for fine pitches. Pitches as fine as 200 microns, arranged in one or two rows, is possible with solder reflow.



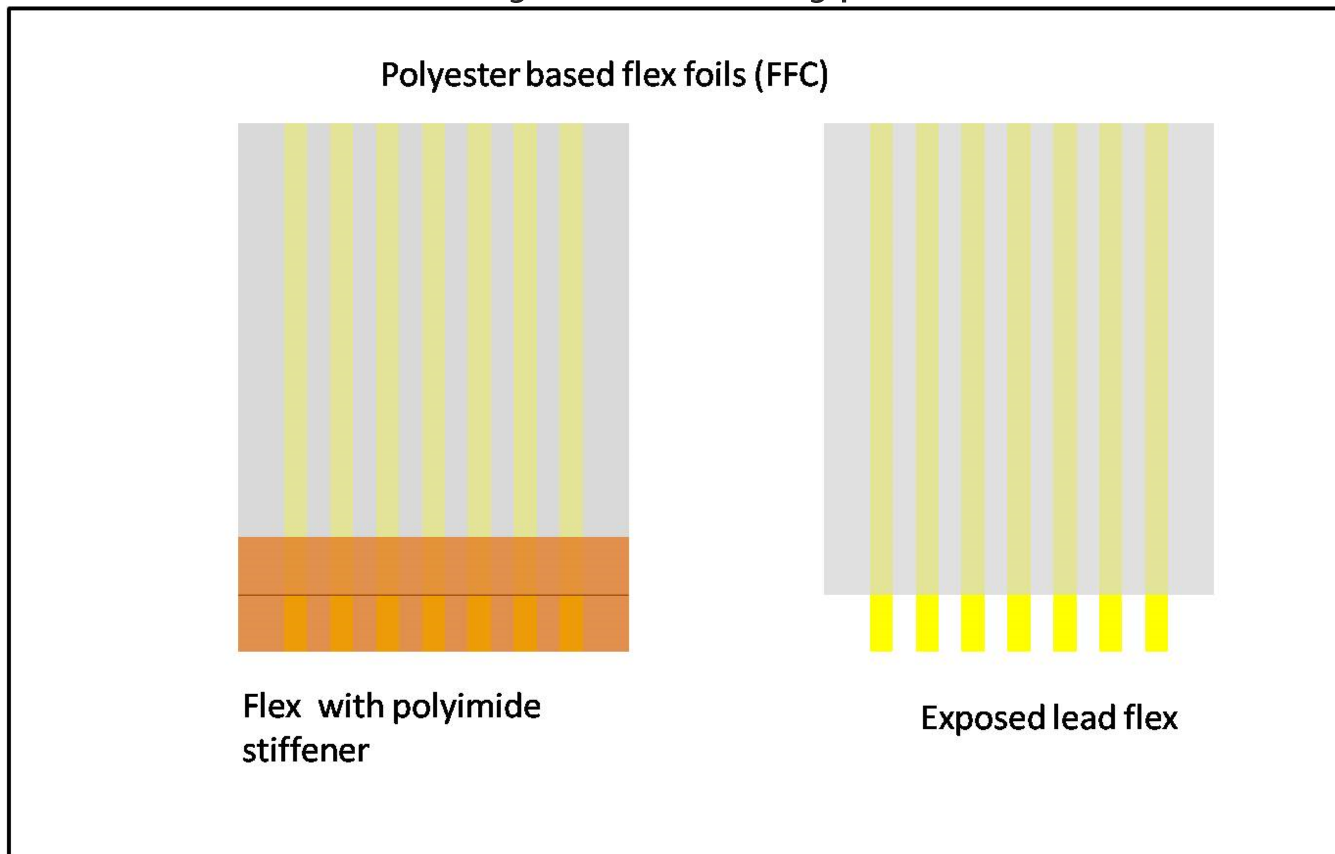
# Flex Design: Connection Type

**Exposed lead flex design:**
This design has both sides of the polyimide (kapton) material removed, leaving the traces free of insulation. The Hotbar contacts the traces directly and conducts heat to the parts. If the PCB pads and Hot Bar footprint are sized correctly, this design will be most tolerant to excess solder on the pads, because it allows solder to flow into open areas. During the process, solder will also wet to the top of the trace. Caution must be used when handling these circuits, as the traces may be easily bend and be damaged. Because the Hotbar comes in to direct contact with the leads, this design will require lower Hotbar temperatures and shorter process times. The Hotbar will pollute with flux residues, and therefore require cleaning. An interposer feeder option kapton feeder module will solve these issues.



# Flex and PCB design: Connection Type

Polyimide flex types

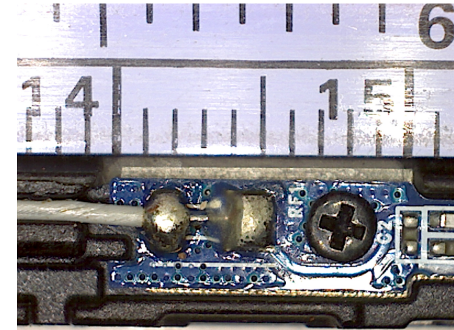


# Wire and PCB design: Connection Type

For Wire-PCB soldering up to thermode length of 40 mm

PCB track design recommendations:

- PCB track width: > 150% of wire-diameter
- PCB track length:>3mm
- Minimum pitch (centre-centre track): 0.8mm
- Minimum spacing between tracks: 0.4mm



Wire recommendations

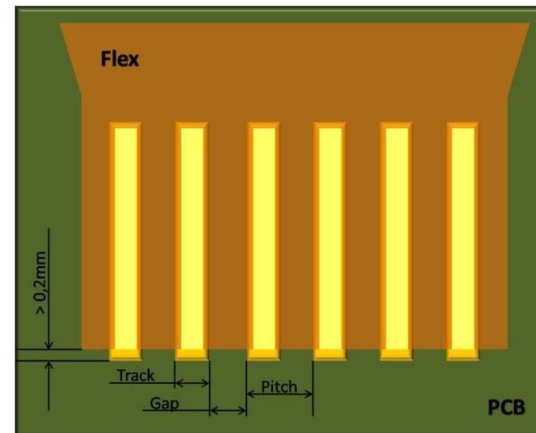
- Wire stripped length minimum: PCB track length

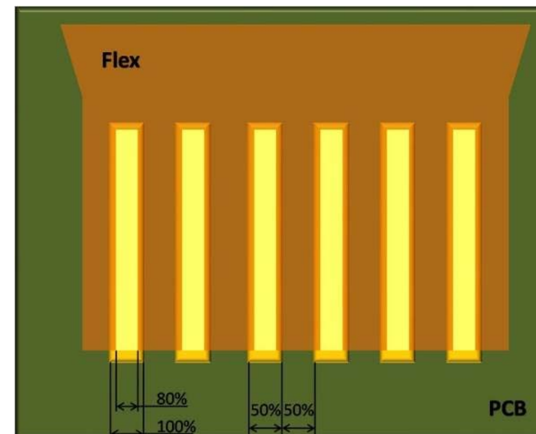
Pre-tinning of parts

- Estimated pre-tinning height on the PCB tracks: 50-80 microns
- Each individual wire in the cable must be pre-tinned to enable a solid wire prior to the solder process

# Design guidelines

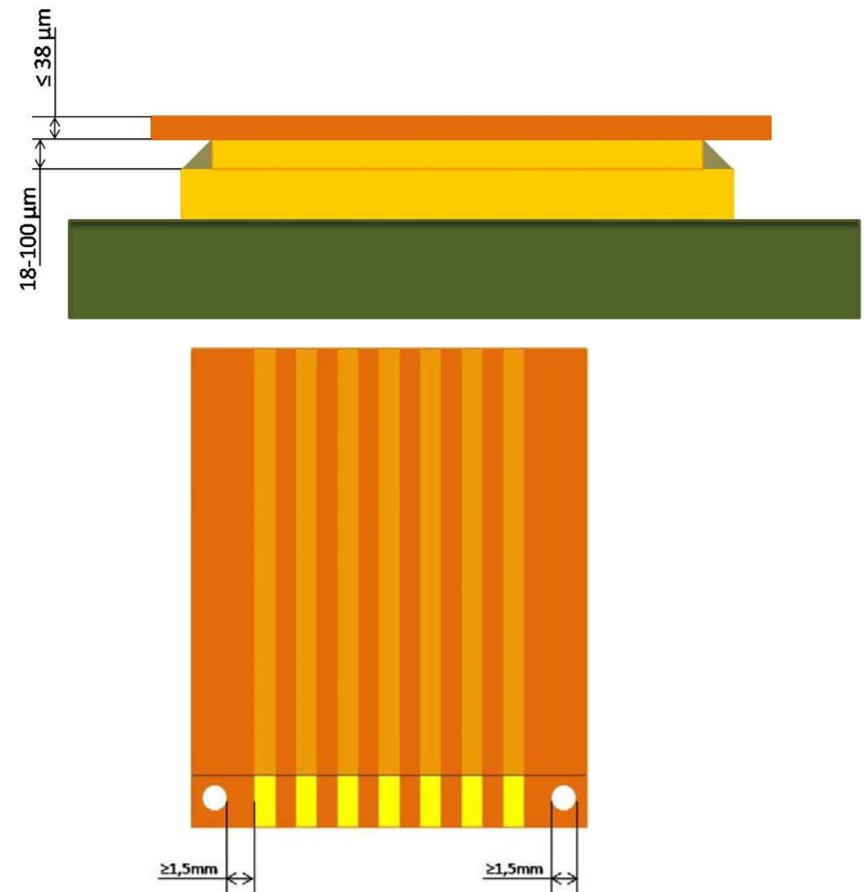
- Track and gap of PCB should be both 50% of the pitch
- Track of the flex should be 80% of the track of the PCB
  - this allows excessive solder to flow
- Flex tracks should be approx. 0.2mm shorter than PCB tracks
  - Visual inspection possible
  - Easy alignment check
  - Allow excessive solder to flow



# Design guidelines

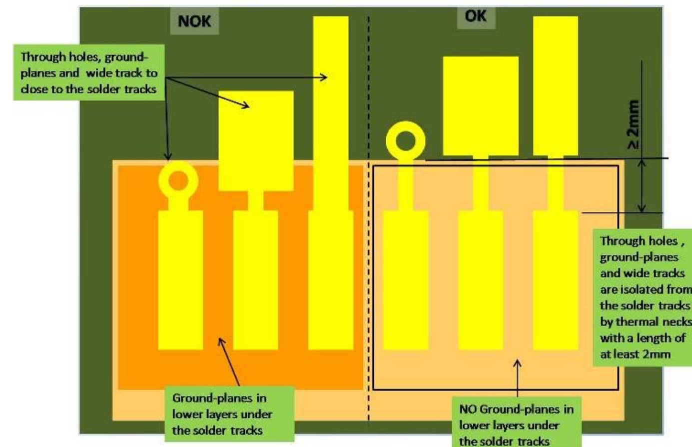
- Thickness of polyimide in solder area should be as thin as possible
- Recommended diameter for locating pins should be at least 1.5mm
- Locating pins should have a minimum distance of 1.5mm from the outside tracks

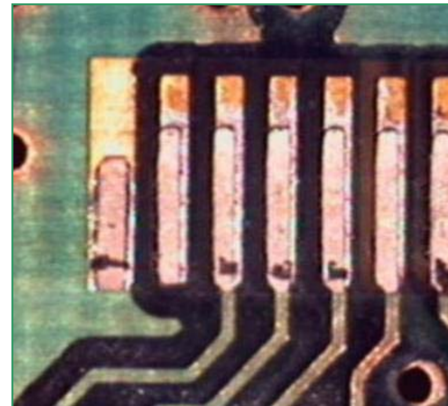


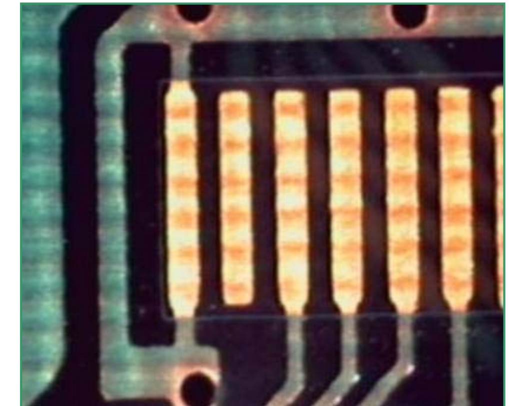
# Design guidelines

- Ground planes and through holes should be isolated from the tracks with thermal necks with a length of 2mm and a width as small as possible

- Ground planes in layers below the soldering area should be minimized in size and mass





# Flex and PCB designs: pre-tinning

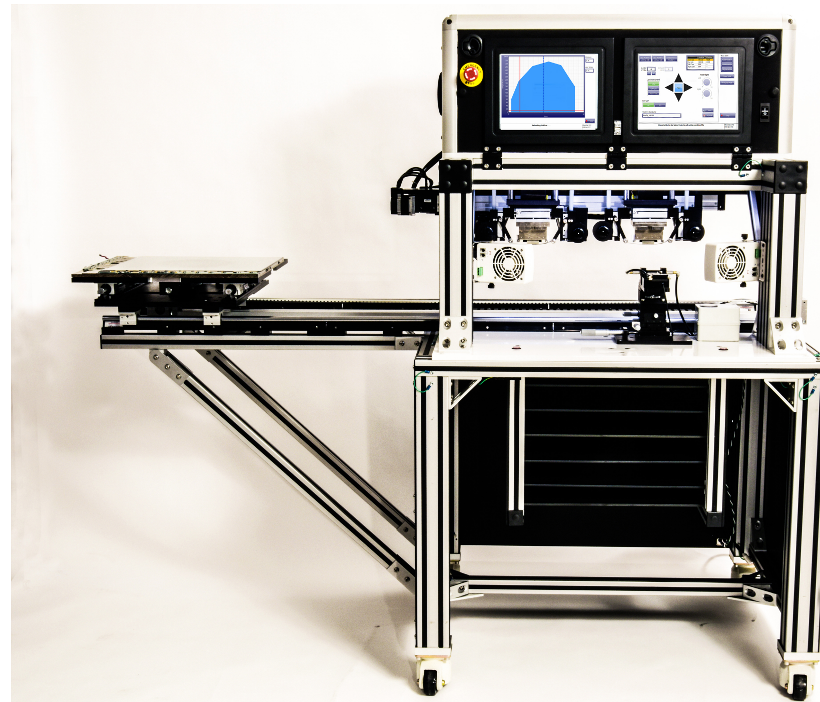
- Solder must be pre-tinned on PCB prior to Hotbar process
- Start point for screen printing is a 150 microns thick stencil with a mask opening that results in a 40% pad coverage.
  (After reflow oven approx 40 % of the solder paste remains)
- For small pitch applications it is recommended to pre-tin the parts by electro plating as being the most accurate technology.

# Benchtop Reflow Soldering Systems

TODDCO's Benchtop Systems are a line of semi-automatic systems developed for Hotbar Soldering, Heat-Seal Bonding and ACF Laminating. The benchtop models deliver the same bonding quality as the larger and more automated systems. For all production environments where labor costs are conservative, it offers an ideal price-performance (throughput) ratio. TODDCO's TG Series systems afford a considerable amount of flexibility, making them perfectly suitable for R&D environments as well.

# TODDCO Reflow Soldering Systems

TODDCO has a proven track record of success with both automatic and semi-automated units. TODDCO offers decades of experience when screening the feasibility of your application. Proof of concept and first article assembly are also available through TODDCO.



Enjoy maximum process stability and excellent reproducibility with our reliable and proven Reflow Soldering systems. Typical projects include repair systems, systems for attachment between PCBs, flex-foils, LCD's and other components, in both semi-automated and fully automated production lines.

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*Troubleshooting Guide*

# Hotbar Reflow Soldering Troubleshooting Guide

| Problem | Possible Causes | Possible Root Causes | Possible Solutions |
|---|---|---|---|
| **Open solder joints** | Not enough heat transfer to the leads | Low process temperature | Increase Hotbar temperature |
| *These solder joints can be:* | | | Increase process time |
| *> random* | | | Adjust coplanarity of Hotbar |
| *> always left or right* | | | Improve supporting fixture |
| *> only one specific joint* | | | Reduce heat loss through fixture |
| *> all joints* | | | Reduce flux amount |
| *> at the edges or at the center* | | | Increase flux drying time |
| | | Uneven heating across leads | Improve product design |
| | | | Improve fixture design |
| | Not enough pressure on the leads | Not enough force | Increase force |
| | | | Reduce Hotbar width |
| | | Uneven force across leads | Improve supporting fixture |
| | | | Adjust coplanarity of Hotbar |
| | | | Improve part flatness |
| | | | Improve variable part thicknesses |
| | | | Clean Hotbar |
| | Poor solder wetting on surfaces | Wrong flux | Change flux type |
| | | Not enough flux | Increase flux amount |
| | | Old flux | Change to new flux |
| | | Dried up flux | Reapply flux |
| | | Uneven flux distribution | Improve flux distribution |
| | | Unactivated flux | Increase flux activation time |
| | | Too much pad oxidation | Clean leads and PCB |
| | | Wrong flex or PCB pad surfaces | Change surface treatments |
| | Not enough solder | Not enough solder | Increase solder amount |
| | | | Improve solder positioning |
| | | | Improve solder shape |
| | | Gap bridge is too large | Improve supporting fixture |
| | | | Increase Hotbar width |
| | | | Increase Hotbar pressure |

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# Hotbar Reflow Soldering Troubleshooting Guide

| Problem | Possible Causes | Possible Root Causes | Possible Solutions |
|---|---|---|---|
| Solder bridging | Too much pressure on the leads | Too much force | Reduce force |
| | | Uneven pressure distribution | Improve flatness |
| | | | Adjust coplanarity of Hotbar |
| | Too much solder | Too much solder | Reduce solder amount |
| | | | Change solder position |
| | | | Change solder shape |
| | | Not enough space for solder to flow | Reduce Hotbar width |
| | | | Increase Hotbar bevel |
| | | | Increase flexibility of the flex |
| | Solder mask to wettable | Not enough seperation room | Decrease pad width |
| **Solder balling** | Too much vapor pressure from flux | Flux not dry | Increase wait after applying flux |
| | | | Increase rise time length |
| | | | Adjust coplanarity of Hotbar |
| | | | Use flux activation step |
| | | Too much flux | Reduce flux amount |
| | | Wrong flux | Change flux type |
| | Too much solder | Enlarge space | Increase pad width |
| | | | Increase pad length |
| | | | Reduce Hotbar width |
| | | | Increase flexibility of the flex |
| | | Reduce solder amount | Reduce solder amount |
| | | | Change solder position |
| | | | Change solder shape |
| | Too much contamination | Remove contamination | Clean parts |
| | | | Avoid contamination |
| Burning | Temperature too high | Hotbar too hot | Lower Hotbar temperature |
| | | | Increase Hotbar width |
| | | | Reduce process time |
| | | Not enough heat dissipation | Increase pressure |
| | | | Improve flatness |
| | Wrong materials | Material is not temperature resistant | Change materials |
| | | | Use thinner materials |