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SMT – Thermal Profile Board Guidelines

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Agenda

- Definition of a profile board
- Generic Guidelines
- Thermocouple Attachment Methods
- Thermocouple attachment for BGA's
- Key to successful thermal profiling

“ The purpose of this document is to define the process of preparing Thermal Profile Boards”

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Profile Board Definition

- A profile board, typically refers to a temperature profile board or a thermal profiling board. This board is used to monitor and optimize the soldering process during the reflow soldering of electronic components onto a printed circuit board (PCB).
- The reflow soldering process involves heating the PCB to a specific temperature to melt the solder paste, which then forms a connection between the electronic components and the PCB. The temperature profile board helps in understanding and controlling the thermal characteristics of this process.

Profile Board Definition

- The profile board is prepared by attaching thermocouples to the various parts of the Assembled board.
- The sensors on the profile board measure the temperature at various points on the board during the reflow process. This data is then used to create a temperature profile graph that shows how the temperature changes over time during the reflow process.



Generic Guidelines

- There MUST be separate profile boards for
 - SMT Bottom
 - SMT Top
 - Wave soldering
 - Rework (PTH, BGA)
- Thermal profiles are verified before each run.
- Thermocouples are properly attached to the specified components and are verified regularly.
- There must be enough thermocouples on each PCBA as per the guidelines.

Generic Guidelines

- Panelised PCBA's must have all the circuits completely populated with the components.
- Operator or engineers must be properly trained and certified for creating profile boards and generating thermal profiles.
- The profile programs must be controlled and can be edited only by the authorised persons.
- Every time a product is moved from one line to another, the profile must be verified as per solder paste supplier recommendations.
- The process window needs to be monitored as per the guidelines.

Thermocouple Attachment Methods

- The accuracy of thermal profiles depends on how accurately the thermocouples are attached to the PCBA.
- There are 3 methods which are commonly used in the Industry for thermocouple attachments.
 - ✓ High temperature soldering
 - ✓ Adhesives
 - ✓ Adhesive tape
- All these 3 methods have its own pros and con's.

Comparison

TC Attachment Method	PRO's	CON's
High Temperature Solder	• Good thermal conduction minimizes the error even if the TC wire is slightly off the surface or the pad. • Strong mechanical attachment needs low maintenance of the profile boards	• Time consuming • Requires high soldering skills for high temperature soldering • Cannot be used for non solderable surfaces
Adhesives	UV Activated Adhesives • Can be used for non solderable as well as solderable surfaces Epoxies • Can be used for both solderable and non-solderable surfaces • Easier and quicker process compared to high temperature soldering	• Easier to pop up in oven after multiple cycles • Relatively poor thermal conduction makes it essential for the TC to touch the surface securely while the adhesive is activated.
Adhesive Tapes	• Easy to use • Non-destructive. Tape can be applied again and again on the same surface. • Can be used on any kind of surface	• Tape's adhesive grips loosens on higher temperatures making the connection between the TC and the surface. The loose contact will measure the ambient temperature rather than the surface temperature • It is difficult to apply tape in tight places, such as between components.

Thermal Mass – Various Stages

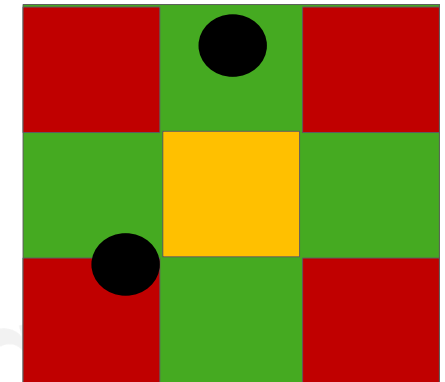
Each profile board needs to represent the thermal mass during the process.

Profile Board for Assembly Step	Components To be populated		
	SMT Bottom	SMT Top	Wave Soldering
SMT Bottom	✓	✗	✗
SMT Top	✓	✓	✗
Wave Soldering	✓	✓	✓

BGA Rework profile board should represent the same condition as the board needs to be reworked.

Thermocouple Spread on PCBA

- Thermocouples should be spread across the whole length and width of the PCBA
- Try to cover TC's diagonally across the PCBA
- Ensure key components such as BGA, QFP, SMT Connectors and some Chip components are selected for profile verifications.
- Usually, 5-6 Thermocouples are used on a PCBA for best thermal profiling.



Thermocouple on the diagonal of the PCBA



Thermocouple on the Centre of the PCBA



Thermocouple on the critical component on the PCBA

Thermocouple For BGA

❖ SMT Process

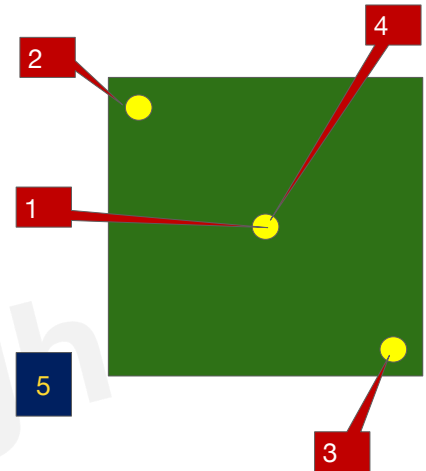
- Large BGA should have TC 1,2,3 & 4 attached
- Small BGA should have TC 1,2 & 4 attached.

❖ BGA Rework

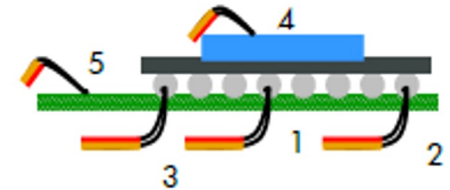
- Attach all 5 TC Wires

❖ Wave and Mini wave Rework

- Closest ball to solder pot opening

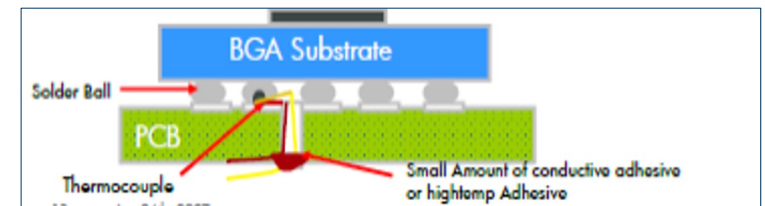
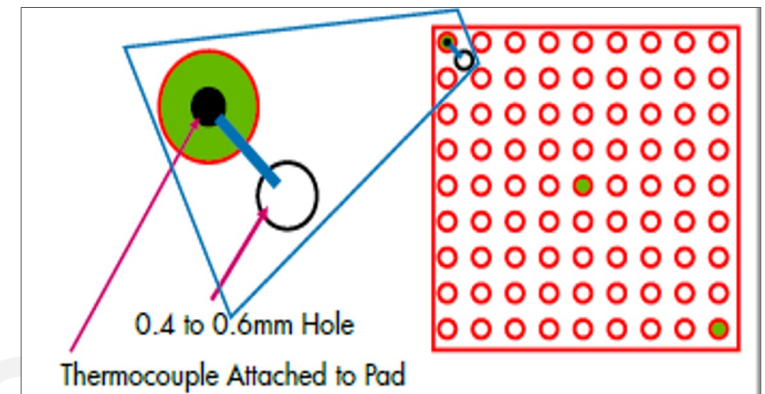


TC Number	Location
1	Centre ball of the BGA
2	One corner of the BGA
3	Other corner of the BGA
4	BGA Top side
5	Near by component



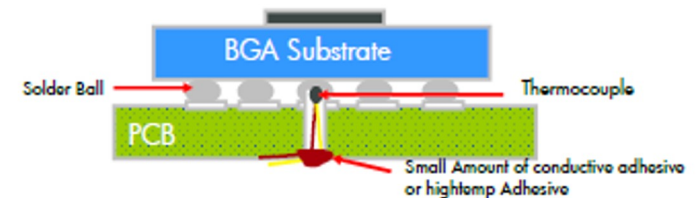
BGA TC Attachment Method - 1

- Drill a hole near the BGA Ball, where we need to put TC wire.
- Attached thermocouple to the pad and then place the BGA device on top.
- Inspect the presence and accuracy of TC wire using X-Ray machine.



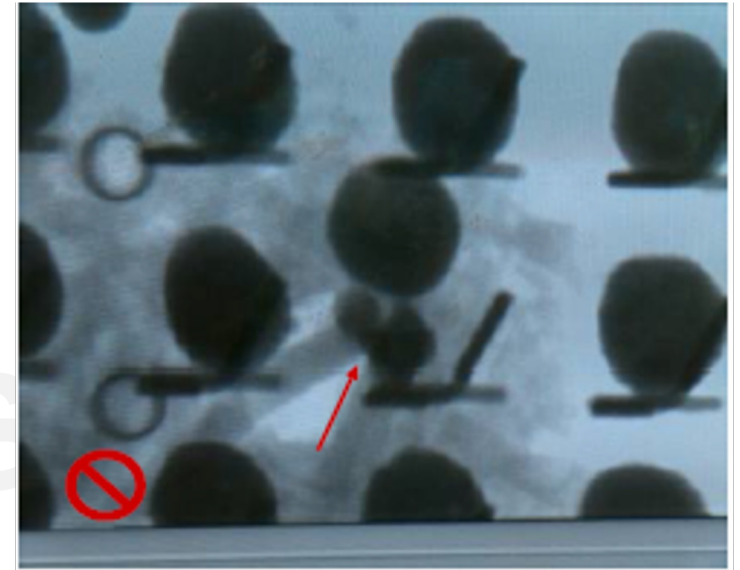
BGA TC Attachment Method - 2

- Drill a hole of 0.55mm through the PCB, exactly where the BGA ball is and attach the TC using adhesives.
- Inspect with X-Ray.
- If the ball is damaged, then drill another hole through the PCB pad and attach thermocouple to the pad and the install the BGA device on the top.

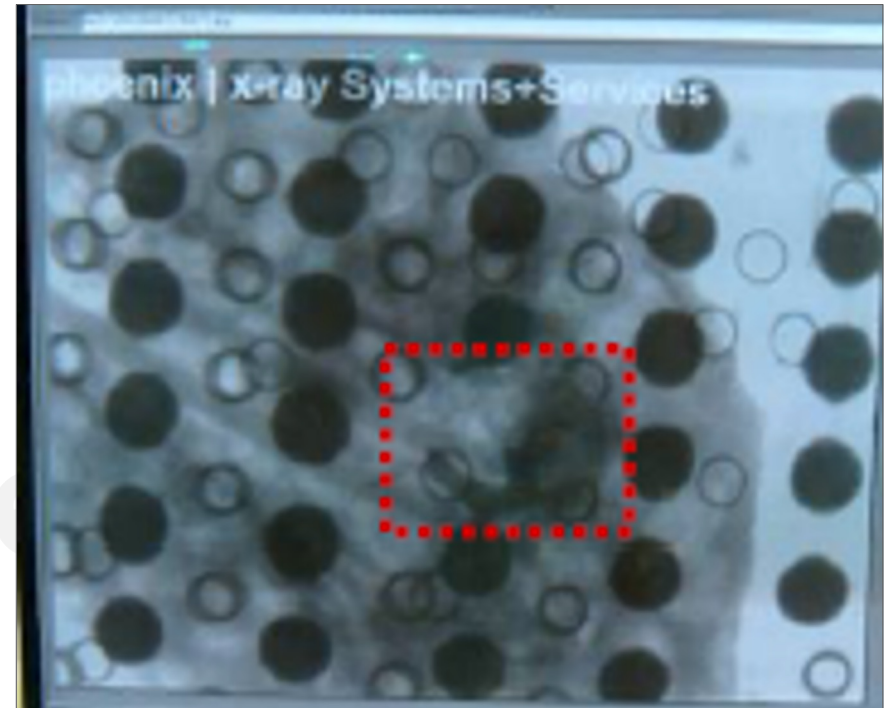


BGA TC Inspection

- Use microscope to inspect and make sure the hole is drilled into the BGA ball.
- Ensure thermocouple is inside the BGA ball using X-Ray inspection.
- If the thermocouple is outside the BGA ball, the whole procedure needs to be done again.
- During the profile if large delta is observed, it is most likely that the TC wire is not attached to the BGA ball, and it is recording only the reflow ambient temperature not the actual temperature on the BGA ball.

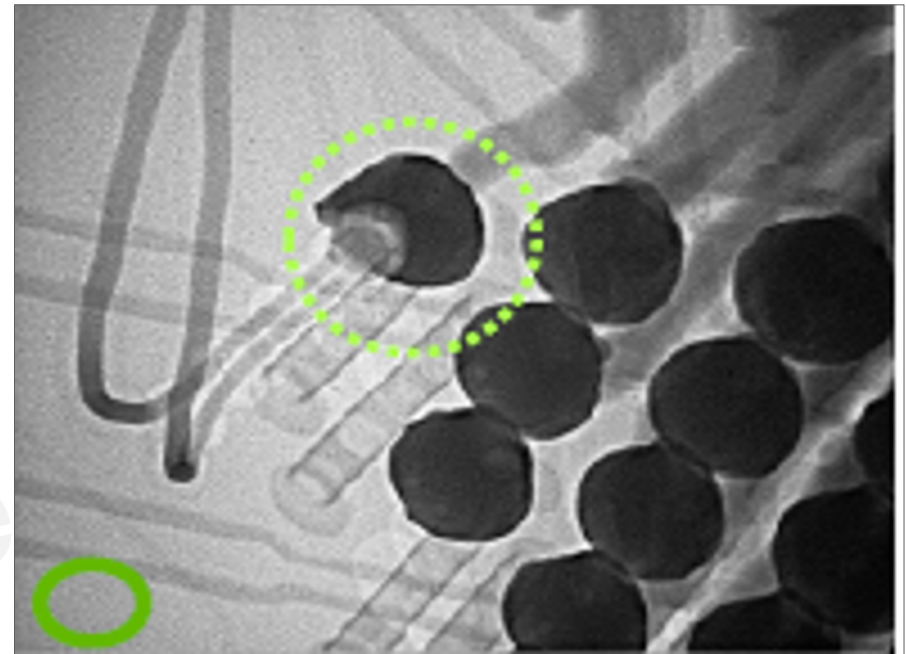
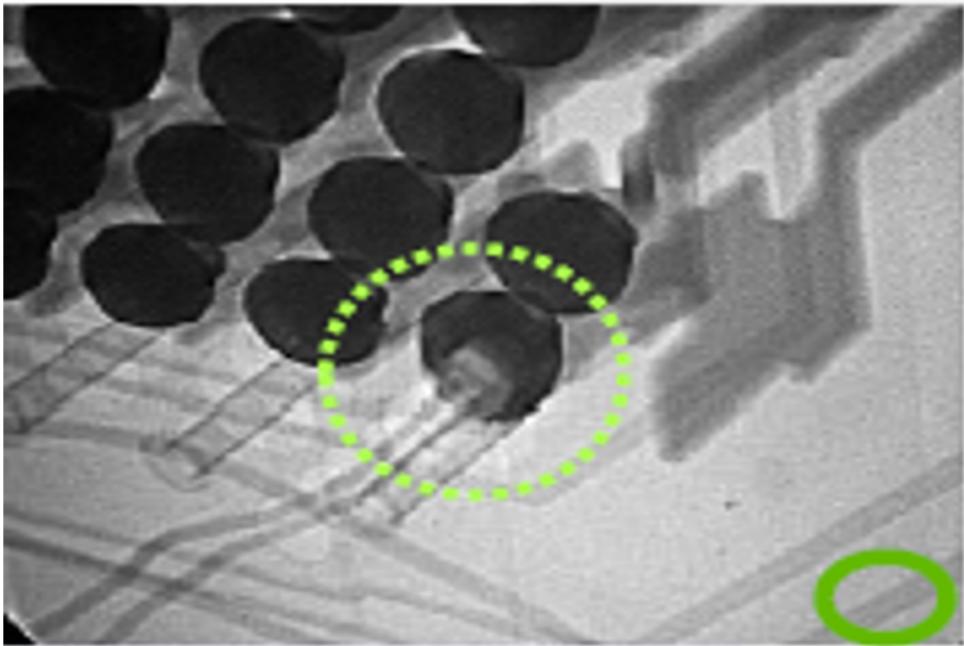


BGA TC Inspection



- BGA ball damaged during thermocouple installation, leaving TC without a BGA ball.

BGA TC Inspection

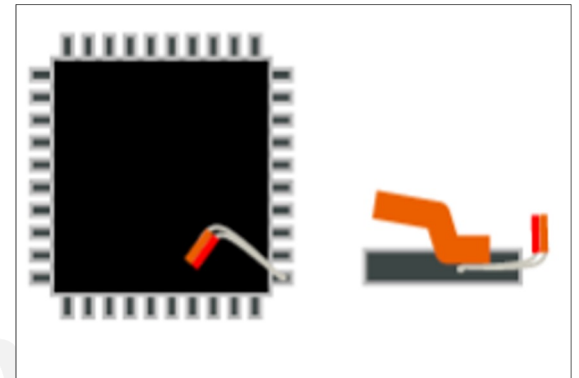


- Correct Installation of TC on BGA balls

SMT Component TC Installation

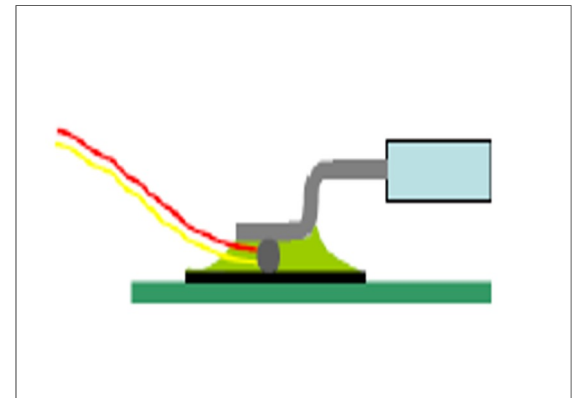
■ ***Gull Wing Device***

- ✓ De-solder the lead of the component and remove all the solder from the pad.
- ✓ Slide TC wire in between the lead and the pad.
- ✓ Solder using high temperature solder.
- ✓ Do not apply glue on the solder lead with the TC.



■ ***Other Lead Types***

- ✓ De-solder and remove the solder from the pads
- ✓ Solder thermocouple using minimum amount of high temperature solder.

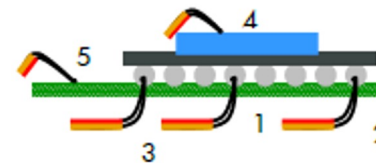
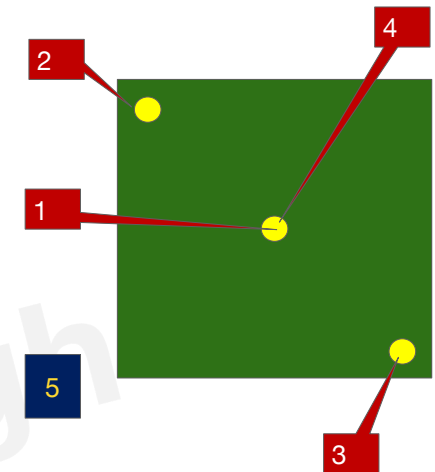


Reflow Profile Guidelines

- As a rule, the temperature variance among all the thermocouples on a BGA should be within 5°C.
 - In total, the temperature difference (ΔC) across various thermocouples on any PCBA should be kept below 15°C
 - The minimum is the temperature difference (ΔC), the better it is for achieving the best soldering quality.
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BGA Rework Profile Board

- ❖ A dedicated profile board is required for BGA rework.
- ❖ All BGA should have all the 5 TC locations as defined in the table.
- ❖ Profile must be taken for removal as well as replacement of the BGA.
- ❖ If another BGA is within 400 mils of the BGA to be removed, corner solder balls should also be measured for the adjacent BGA.
- ❖ Proper shielding is also required on adjacent BGA's while doing the rework.



TC Number	Location
1	Centre ball of the BGA
2	One corner of the BGA
3	Other corner of the BGA
4	BGA Top side
5	Near by component

Key to Successful Thermal Profiling

- Proper Placement:
 - ✓ Thermocouples should be strategically placed across the PCB to capture temperature variations accurately.
 - ✓ Position them in critical areas where temperature changes significantly, such as near BGAs, QFNs, or areas with high component density.
 - Secure Attachment:
 - ✓ Ensure that thermocouples are securely attached to the PCB to prevent movement during the reflow process.
 - ✓ Use heat-resistant tape or other appropriate methods to secure the thermocouples in place.
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Key to Successful Thermal Profiling

- Consistent Connection:
 - ✓ Maintain consistent electrical connections for the thermocouples to ensure reliable temperature data.
 - ✓ Check for loose connections or damaged wires that could compromise the accuracy of the temperature profile.
 - Verification:
 - ✓ Regularly calibrate and verify the accuracy of the thermocouples to ensure they provide reliable temperature measurements.
 - ✓ In case there are temperature variations, make sure the rework or corrections are performed on the profile boards accordingly.
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Key to Successful Thermal Profiling

- A details internal procedure needs to be developed internally on the the profile board management in terms
 - Commercial approvals or investments (PCBA, TC Wires etc)
 - Storage of the profile boards
 - Periodic verification of profile boards (Recommended every month)
 - Skill monitoring of technicians trained on creating profile boards, it is one of most difficult skills in SMT line.
 - By paying close attention to these critical points, you can enhance the reliability of temperature measurements during the reflow soldering process, leading to better control and optimization of the PCB assembly
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Do you have more questions on topic ?

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Thank You

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