iNEMI LEAD-FREE MICRO-BGA, CBGA, MICTOR CONNECTOR AND THROUGH-HOLE PDIP REWORK EVALUATIONS

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ABSTRACT

A team of iNEMI (InterNational Electronics Manufacturing Initiative) companies collaborated to develop Tin-lead and Lead-free rework processes for double-sided printed circuit boards in three thicknesses (0.062”, 0.093” and 0.135”) with electrolytic NiAu and Immersion Ag surface finishes.

As a prelude to the rework development of the iNEMI Payette designed test board in Phase 2 an initial rework development phase was conducted (Phase 1). The initial phase was performed on a HP “Yunque” test board with similar board characteristics to the Payette board. One of the components for rework development in Phase 1 was a 5-segment Mictor connector.

This paper will present the Tin-lead and Lead-free rework development processes developed on the Phase 1 boards for the Mictor connector component as well as highlighting and analyzing certain areas of concern caused by reflow issues for adjacent CBGA parts during Micro-BGA rework, and reduced hole-fill during mini-pot rework activities on PDIP16 components for the Phase 2 iNEMI Payette board.

Keywords: Rework, Lead-free, Connector, BGA

INTRODUCTION

The first iNEMI Pb-free project [1] had helped to lay the foundation for Pb-free manufacturing and reliability processes using 62mil thick test vehicle boards, including the selection and recommendation of the SnAgCu solder alloy. However, it was recognized that more development work was needed for rework and wave soldering and to extend manufacturing process development to larger thicker thermal mass printed circuit assemblies. To accomplish this, a new project was initiated that included rework studies for large, complex, high thermal mass component board assemblies, representing IPC Class 2 second level assembly manufacturing for board thicknesses of 93mil and 135mil.

Phase 1 development looked at developing lead-free rework processes for various component types including components, which had not typically been evaluated for rework including Mictor connectors. Phase 2 development evaluated rework on a test vehicle, which attempted to simulate a product type board, and also could be reliability tested. The following sections will discuss rework of Mictor connectors on Phase 1 HP Yunque boards and rework of CBGA and UBGA components in terms of the interaction between the 2 components during rework on Phase 2 iNEMI Payette boards as well as through-hole rework on PDIP components on the same board.

EXPERIMENTAL

Mictor Connector Rework (Phase 1)

Mictor Connector Rework development was conducted on the HP Yunque test board. The topside of a 12” x 18” x 0.135” HP Yunque test vehicle is shown in Figure 1.

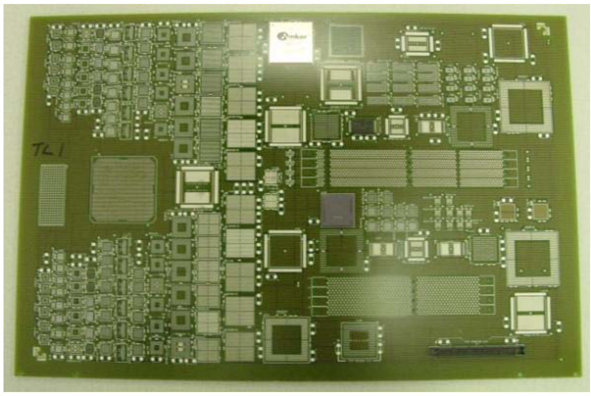

Figure 1: HP Yunque test board.

The Mictor connector had peripheral surface mount technology (SMT) lead-frames and center row pin through-hole (PTH) terminals. Due to the SMT and PTH interconnect designs combination, a hot gas rework system was used for developing the process for removing and replacing the Mictor connector for a tin-lead and lead-free SnAgCu rework process.

A Mictor connector had not traditionally been reworked using a hot gas rework system for either a SnPb or lead-free process. For this portion of the project, a 5-segment Mictor connector was evaluated for the rework process that included removal, site redressing, and part replacement using a hot gas rework equipment. The rework study was performed in two steps.

Step 1 was rework process development with emphasis on the rework profiling. The rework development was performed for both tin-lead and lead-free (SnAgCu) assemblies on two different board thicknesses (62mil and 135mil) of the HP Yunque Test Board. The rework profile development took into consideration the package, board, and solder paste specifications.

Step 2 of this study used the rework process developed in Step 1 to rework one Mictor connector on a 135mil thick test board. Once assembled the reworked connector was x-rayed, visually inspected and cross-sectioned for metallurgical analysis to determine the component body and solder joint integrity.

The information on the test vehicle, component and board is listed below for the Mictor connector rework on the Phase 1 board.

Test Vehicle
- HP Yunque Test Board
- High Tg Laminate Material (Tg: 170°C)
- Board Thickness and Finish: 0.062”(NiAu board finish),0.135”(Imm.Ag finish)
- Board Dimensions: 18”x12”
- No. of copper layers:

Component
- 5 Segment Mictor Connector 190 pin
- Component Pitch: 25mil
- Component coating: pure tin
- Board Location: J17 (close to edge of the board)

Solder Paste
- Tin-Lead: 63Sn37Pb (no-clean) Type 3
- Lead-free: Sn3.9Ag0.6Cu (no-clean) Type 3

Rework Equipment
- Hot Gas Convection Rework Machine A
- Air Atmosphere used
- Custom Rework Nozzle
- Non-contact scavenger device for site redressing

Rework Mini-Stencil
- Thickness: 6mils

Thermoprofiler and Thermocouples
- Machine A system profiler
- K-type thermocouples

K-Type thermocouples were used to monitor the temperature of the Mictor connector for both the 0.062” and 0.135” thick boards. The thermocouples were attached at the SMT and PTH solder joints, on the connector body, and on the PCB near the reworked component. The diagram in Figure 2 shows the locations of the thermocouples on the Mictor connector.

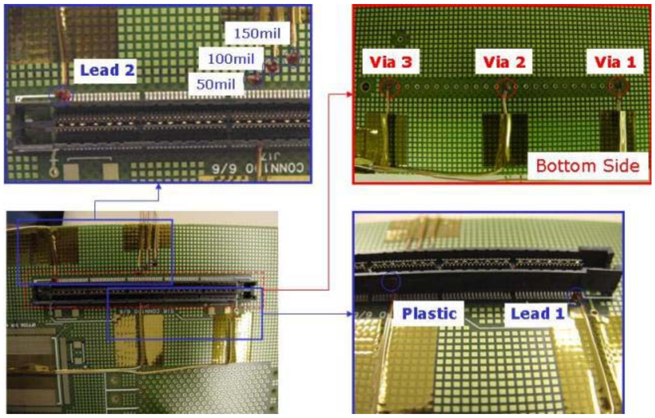

Figure 2: Mictor thermocouple locations.

The rework boards were secured along the edges and had support on the bottom side. A custom rework nozzle was checked for coplanarity on a flat surface prior to securing onto the rework machine. Figure 3 shows a photograph of the nozzle used for reworking the Mictor connector. Once secured, the nozzle was lowered to the surface of the board to ensure the nozzle was parallel. This was key to having uniform heating along the peripheral leads of the Mictor connector during the reflow cycle.

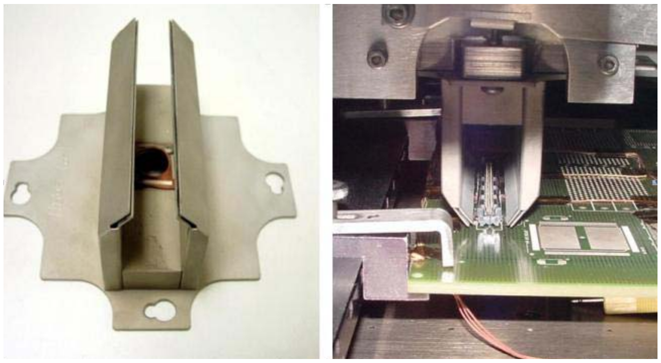

Figure 3: Mictor rework nozzle and its use on the HP Yunque board.

From previous rework development, a gradual ‘volcano’ type profile was targeted as the preferred profile while observing the target reflow conditions. The target reflow conditions were for lead-free SnAgCu soldering, a minimum soldering peak temperature of 230°C and a maximum component body temperature of 260°C. The gradual volcano reflow profile type was to help minimize the thermal gradient between the package and the solder joint temperature.

Once the rework profiles were developed for 63mil and 135mil thick boards, rework was conducted. After the component removal process, a non-contact scavenging nozzle was used to redress the site to help minimize the potential for pad damage. Similar to the SMT assembly process, a stencil was used to deposit solder paste on the redressed sites. The mini-stencil had the same aperture openings and stencil thickness as a normal SMT stencil for this component. The mini-stencil was fixed onto a rod for ease of handling during the paste printing process. Paste is deposited by aligning the mini-stencil over the site and "rocked" back and forth to release the paste.

CBGA and uBGA Rework (Phase 2)
The topside of a 7" x 17" x 0.135" test vehicle named NEMI Payette is shown in Figure 4, was used in Phase 2.

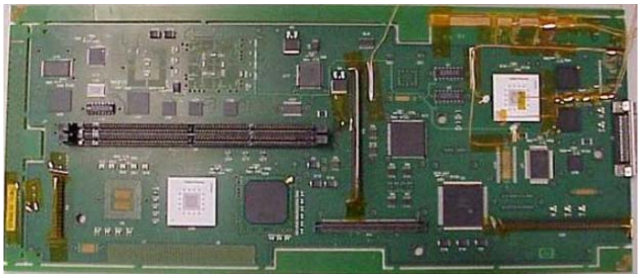

Figure 4: NEMI Payette board (topside).

The topside rework included uBGA, PBGA and CBGA components.

The following parameters were considered in Area Array rework package development for the CBGA937 and UBGA256 components.

Array Packages (Phase 2)
The different components on the boards were reworked by different rework sites due to the volume of rework involved. In certain cases this led to different orders/sequences of rework for the reworked components on the iNEMI Payette board which included the rework of the two CBGA and two uBGA components as well as two PBGA544 components.

Below is a list of considerations for the assembly used in the rework development.

- Conventional hot gas rework equipment: Machine A
- Board thickness and surface finish: 0.093" (Imm Ag and Electrolytic NiAu) and 0.135" (Electrolytic NiAu)
- Components and U location: uBGA256 1mm pitch (locations U40, U41), CBGA937 1mm pitch (locations U27, U28)
- Component spheres: SnPb and SnAgCu
- No-clean Solder Pastes: Sn3.9Ag0.6Cu and Sn37Pb
- Atmosphere: Air
- No. of copper layers: 14
- Laminate type : High Temp Laminate FR4 (Tg: 170°C)

DIP16 (Phase 2)
The same board was used as in Figure 4 for the PDIP 16 rework. The following parameters were considered in PTH rework development:

- Mini-pot Solder fountain equipment A
- Board thickness and finish: 0.135" (Electrolytic NiAu)
- Board Dimension :16.5" x 7.25"
- Laminate type : High Temp Laminate FR4 (Tg: 170°C)
- No. of copper layers: 14
- Solder Alloys: SnAgCu and SnPb
- Wave flux: No-clean water based VOC-free
- Atmosphere: Air
- Pre-heater (when needed) : BGA Rework Machine B
- Rework nozzle: 0.484" (12.29mm) x 0.955" (24.26mm)
- Component: PDIP16 (tin-lead and lead-free pure tin)

The joints formed on PDIP16 by the two alloys were visually inspected after 1st pass wave assembly and rework which were both conducted on the same mini-pot rework machine.

The DIP16 components supplied were categorized into those having coating of lead-free pure tin for SnAgCu soldering and those with tin-lead coating for SnPb soldering.

Thermocouples were attached to the component and the Payette board at six locations described below.

- TC 1, Topside of Component
- TC 2, Thermocouple inserted underneath bottom side of component
- TC 3, Topside of board under the component
- TC 4, Through hole (Expose slightly at bottom side)
- TC 5, 0.15" from leads of component (Topside)
- TC 6, Bottom side of board

From experimental data, the peak temperature of the component at the top and the temperature at the bottom side of the board had to conform to the previous J-STD-020B standard [2]. Thermocouples readings on the PDIP16 for the two different SnPb and SnAgCu pot temperatures were found to conform to J-STD-020B.

The actual experiment consisted of first pass wave soldering of DIP16 on three PDIP16 locations on the NEMI Payette board (U1, U2, and U18). The component was then removed and the through-hole site redressed followed by a second pass rework soldering. An adequate amount of flux was sprayed from the bottom-side with the use of an atomizer type sprayer.

DIP16 integrated components supplied had leads that were shorter than the board thickness of 135mil thick and thus observations could not be conducted from solder joints formed on the bottom of the inserted leads. Visual analysis was thus conducted based on hole fill achieved analyzing for topside solder joint fillets formation.

RESULTS AND DISCUSSION

Mictor Connector Rework Phase 1

All four rework profiles were developed on 63mil and 135mil thick boards, two for SnPb and two for lead-free SnAgCu which are summarized in Table 1. Multiple attempts were conducted to improve the rework profiles to reduce the large delta T between solder joint and component package with no success. Additionally a significant thermal gradient was observed from one end of the connector to the other. After careful examination, it was discovered that the bottom-side heater was not uniformly distributing convection heat along the component. The bottom heater consisted of a chamber/plate with pre-drilled holes for hot air to escape through into the board. This hot air was used to heat up the board during rework. However, due to the large size of the board (12 x 18 inch) and the location of the Mictor component near to the board edge, the part of the board where the component was located was not directly over the pre-drilled holes where the hot gas were escaping. In effect, there was insufficient heat into the board at this location with the result that excessive top nozzle was used with the resultant large delta T between solder joint and component.

Table 1: Mictor connector rework profile summaries.

Target Parameters	SnPb			LF SAC		
	Target	62mil	135mil	Target	62mil	135mil
SMT Solder Joint Min. Temp (°C)	200	196.1	216.7	230.0	219.4	236.7
PTH Solder Joint Min. Temp (°C)	200	195.1	196.7	230.0	212.8	219.4
Connector Max Temp. (°C)	245	206.1	215.0	245.0	230.6	245.0
Max Temp Delta Between Solder Solder Joints (°C)	10	13.3	19.4	10.0	28.9	27.8
Temp Btwn Lowest Solder Joint and Conn. Body (°C)	45	11.0	18.3	15.0	17.8	25.6
Min. Time Above Liquidous (TAL) - (sec)	45	65.0	102.0	45.0	0.0	29.0
Max. Time Above Liquidous (TAL) - (sec)	120	115.0	156.0	120	110.0	131.0
Board Temp. 50mil Away from Comp.	-	198.0	208.0	-	230.0	240.0
Board Temp. 150mil Away from Comp.	-	195.0	201.0	-	225.0	233.0

Since the SnPb rework reflow parameters were much lower in temperature than lead-free, a greater effort was placed on developing a rework profile for the lead-free soldered board with the board resized (which could not happen in real life) and repositioned to achieve more uniform bottom side heat.

A 135mil thick board was cut approximately in half and repositioned onto the rework machine. Figure 5 shows the setup for the "As Assembled" board and the "resized" board.

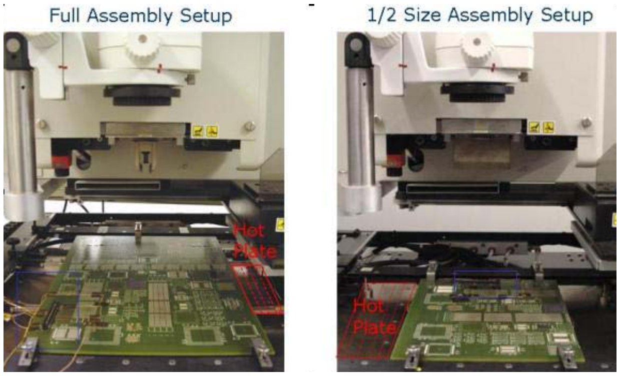

Figure 5: "As Assembled" and the "resized" HP Yunque board.

With the repositioned board in the rework machine, a lead-free reflow profile was developed to bring up the solder joint temperature between the SMT and PTH leads. A comparison between the profiles developed for the full board and the half sized board is outlined in Table 2. A minimum peak temperature of 230°C was achieved for the SMT leads while we did note that the PTH connector body still reached 253°C.

Table 2. Lead-free Rework profile comparisons between as-assembled and resized boards.

Target Parameters	Lead-free SAC - 135mil		
	Target	Full Size	Half Size
SMT Solder Joint Min. Temp (°C)	230.0	236.7	250.6
PTH Solder Joint Min. Temp (°C)	230.0	219.4	230.0
Connector Max Temp. (°C)	260.0	245.0	253.3
Max Temp Delta Between Solder Joints (°C)	10.0	27.8	22.8
Temp Btwn Lowest Solder Joint and Conn. Body (°C)	15.0	25.6	23.3
Minimum Time Above Liquidous (TAL) - (sec)	45.0	29.0	94.0
Maximum Time Above Liquidous (TAL) - (sec)	120	131.0	167.0
Board Temp. 50mil Away from Comp.	-	240.0	243.0
Board Temp. 150mil Away from Comp.	-	233.0	241.0

With the profiles developed, a sample rework operation and post rework analysis was performed to verify the integrity of the rework attachment. The rework was performed with the lead-free 135mil thick half size test board.

One rework operation was successfully performed using the lead-free profile developed. Visually all joints appeared to be soldered correctly with X-ray analysis showing some voids in both the SMT and PTH solder joints. Representative visual and x-ray photographs are shown in Figure 6.

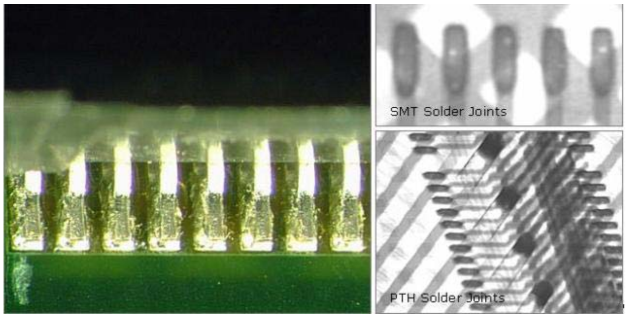

Figure 6: Representative visual and x-ray images of reworked Mictor connector.

Cross-sectional analysis revealed good solder joint wetting and bonding between the solder and the lead-frame/pin and the board. Representative SMT and PTH solder joints are shown in Figure 7.

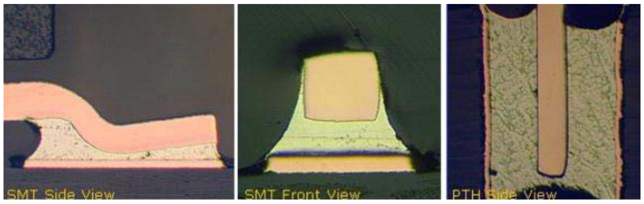

Figure 7: Representative Mictor SMT and PTH soldered cross-sectioned joints.

CBGA and uBGA Rework (Phase 2)

Multiple rework trials were performed before developing satisfactory profiles for the CBGA, uBGA and PBGA components. During lead-free rework maximum peak component body temperatures of 245°C to 250°C were consistently measured in the NEMI Payette board trials attained on the Payette boards using both the 0.093" and 0.135" thicknesses. The lead-free rework processes developed conformed to J-STD-020C specifications [3] for component temperature exposure limits.

For the lead-free profile, the minimum solder joint temperatures were approximately 230°C while the maximum package temperature was approximately 245°C. The new J-STD-020C which has higher temperature limits allowed the much needed wider lead-free process temperature window. In most cases, the board temperature 150mils away from the rework component was above the liquidus reflow temperatures (which was also the case during tin-lead rework). During the profile developments a key challenge was encountered.

With lead-free rework, it was found that the bottom side heater set point needed to be elevated compared to SnPb reflow profiles. This was to help minimize the top nozzle heaters from over heating the top of the package beyond its JEDEC 020C package temperature limitations. Increasing the bottom side heaters to compensate for the reduced top heater nozzle used was found to have an adverse effect on bottom side and adjacent components in terms of exceeding liquidus temperatures. During the uBGA rework, it was observed that the nearby CBGA at location U27 was affected by the heat resulting in open connections. However this was not observed for an adjacent uBGA that was also spaced at a similar distance to the CBGA. It was believed that component construction and size could account for the differences observed.

For a PBGA544 component which was reworked near to the other CBGA at U28 close to the center of the board there were no similar opens reported at U28 CBGA location. The only difference was the U27 CBGA and uBGA component were close to the board edge which indicated the CBGA at U27 had more thermal heat transferred into it the CBGA at U28. This would be another factor to consider.

Shielding of the CBGA using kapton tape during rework of the uBGA was then employed with no subsequent opens observed post rework. However, reliability was found to have decreased for the U27 CBGA and this was believed to be due to the adjacent rework process. Once all rework was performed on test boards for reliability testing, a side experiment was performed to better understand the thermal characteristics of adjacent heating.

Preliminary results showed that the adjacent CBGA had joint temperatures ranging from 211°C to 223°C, with the 223°C being closest to the reworked uBGA. Thermocouples placed at the bottom side of the PCB corresponding to the CBGA joint locations above registered temperatures ranging from 237°C to 245°C. The adjacent uBGA had a solder joint temperature of 245°C. Figure 8 and Table 3 show the results with locations of the thermocouples. Additional work would be needed to help reduce bottom-side and adjacent component temperatures.

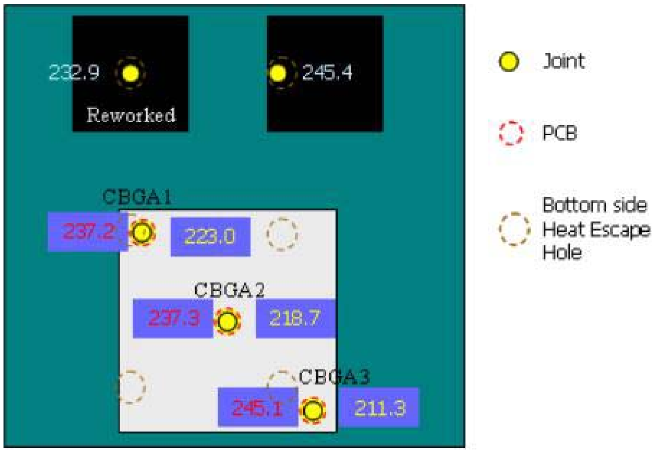

Figure 8: Thermocouple placements on the CBGA and uBGAs.

Table 3: Component, board and solder joint temperature for UBGA and CBGA components.

TC Location	Time >Liquidous (sec)	Peak Temp (C)
Reworked uBGA Joint	103.4	232.9
Adjacent uBGA Joint	149.4	245.5
CBGA 1 Joint	56.6	223.0
CBGA 1 Bottom PCB	124.1	237.2
CBGA 2 Joint	21.7	218.7
CBGA 2 Bottom PCB	121.4	237.3
CBGA 3 Joint	0.0	211.3
CBGA 3 Bottom PCB	153.4	245.1

Figure 9 illustrates the percentage of CBGAs that failed for different test cells. One can see that test cells for the thicker boards (0.135”) after rework are the ones with the highest percentage of failed CBGAs. The reason could be because of the higher bottom-side thermal loads used for these thicker boards during the rework of an adjacent uBGA. Also if a test cell was reworked such that the CBGA was reworked after the uBGA, there were no opens registered for the CBGA after CBGA rework. Controlled experiments to understand the exact mechanism of this failure would be used in a follow-on study [4].

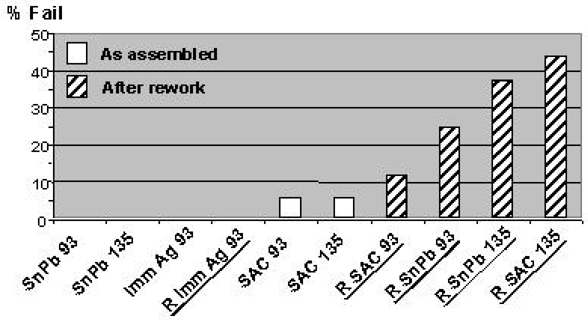

Figure 9: Percentage of CBGA failures at U27 for different test cells (‘R’ indicates reworked board).

DIP16 Phase 2 Through-Hole Rework Development

Rework evaluations were conducted on a through-hole soldered PDIP component on the NEMI Payette board. A SnPb through-hole rework process was used as a baseline. Acceptable hole-fill results were obtained for SnPb reworked with SnPb PDIPs.

Results achieved from performing SnPb plated PDIP16 and SnPb alloy mini-pot wave soldering were good for first (wave) and second (rework) pass soldering using a pot temperature of 260°C (500°F) without preheating the board. This was based on visually inspecting the solder joints formed at leads of PDIP16. With the SnPb portion completed, the next step was soldering of lead-free PDIP16 using SnAgCu alloy.

For the lead-free SnAgCu wave process, different solder pot temperature settings were used in the evaluation: 500°F (260°C) and 525°F (274°C), 550°F (300°C) at different dwell times with and without board preheat on the 135mil thick boards. Top board preheat of 120 °C was provided with an external BGA rework machine as the mini pot used did not have the board preheat capability.

At 260°C (500°F), no sign of topside hole-fill was observed as seen from the topside of the NEMI Payette board. When the pot temperature was raised to 274°C (525°F) acceptable hole-fill was achieved with a dwell time of 10 seconds. Good hole-fill and fillet formation were seen on all PDIP16 leads. With board preheat for 1st pass PDIP16 soldering, acceptable hole-fill could be achieved at lower dwell times.

Removal of the assembled lead-free pure tin coated PDIP was successful with a lead-free SnAgCu pot temperature of 274°C (525°F) using approximately 15 to 20 seconds dwell time**.** Excessive solder were removed and site redress conducted. Reattaching a new component was found to be more challenging.

Second pass (rework) soldering found the pot temperature needed to achieve close to 75% hole-fill was 274°C. Acceptable hole-fill and fillet formation could be seen at dwell times of approximately 30 seconds at 274°C. Tables 4, 5 and 6 compare the results and observations for SnPb versus lead-free SnAgCu soldering of the PDIP component on the iNEMI Payette board showing pot temperatures and dwell times which gives an indication of the increased pot temperatures and dwell times needed for lead-free SnAgCu solder. Figure 10 shows three locations of second pass lead-free soldering. Observations from soldering of SnPb plated PDIP16 with SnPb solder with no board preheat. Observations from soldering of LF PDIP16 with SnAgCu solder with no board preheat.

Table 4: Results and observations for SnPb versus SnAgCu soldering of the PDIP component showing pot and dwell times for 1st pass wave.

	1st Pass (wave)		
Type	**Dwell time (sec)**	**Temp °C**	**Remarks**
SnPb plated DIP16 using SnPb solder Alloy	5 to 8	260	Good hole fill and fillet formed
	1st Pass (wave)		
Type	**Dwell time (sec)**	**Temp °C**	**Remarks**
Pure tin plated DIP16 Using SnAgCu solder	10	260	Unacceptable hole fill and fillet formed
	10	274	Good hole fill and fillet formed

Table 5: Results and observations for SnPb versus SnAgCu soldering of the PDIP component showing pot and dwell times for component removal.

Type	*Component Removal*		
	Dwell time (sec)	Temp °C	Remarks
SnPb plated DIP16 using SnPb solder Alloy	6	260	Smooth removal of DIP16
	Component Removal		
Type	Dwell time (sec)	Temp °C	Remarks
Pure tin plated DIP16 Using SnAgCu solder alloy	15 to 20	274	Smooth removal of DIP16

Table 6: Results and observations for SnPb versus SnAgCu soldering of the PDIP component showing pot and dwell times for 2nd pass rework.

Type	2nd Pass (rework)		
	Dwell time (sec)	Temp °C	Remarks
SnPb plated DIP16 using SnPb solder Alloy	12	260	Good hole fill and fillet formed
	2nd Pass (rework)		
Type	Dwell time (sec)	Temp °C	Remarks
Pure tin plated DIP16 Using SnAgCu solder alloy	20	274	Less than 75% hole fill
	30	274	Acceptable hole fill and fillet formed

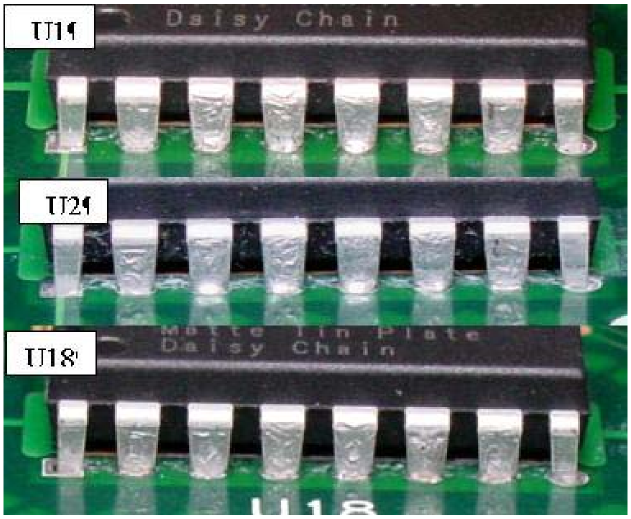

Figure 10: Reworked lead-free PDIP component with SnAgCu solder.

Board preheat was evaluated for lead-free SnAgCu 1st pass and reworked PDIP16 component. The preheat was performed using a BGA hot gas rework machine. Preheating the board prior to the lead-free soldering exhibited better soldering results. The top board temperature for a non-preheated board was at 80°Celsius. As an experiment, we preheated the board to 120°Celsius using the BGA hot gas rework machine and the results showed better hole-fill. Typically current SnPb production processes for these types of boards do not use board preheat for minipot rework. The focus of the work was to emulate current production processes for lead free rework.

Once a rework process was developed, some PDIPs were reworked with SnAgCu. Visual, x-ray and cross-section analysis was performed. Using cross-sectional analysis, it was found that part of the copper pad barrel had dissolved into the solder pot. A representative picture is shown in Figure 11. Additional work would need to be performed to define a workable process to characterize the integrity of the rework for through-hole solder joints.

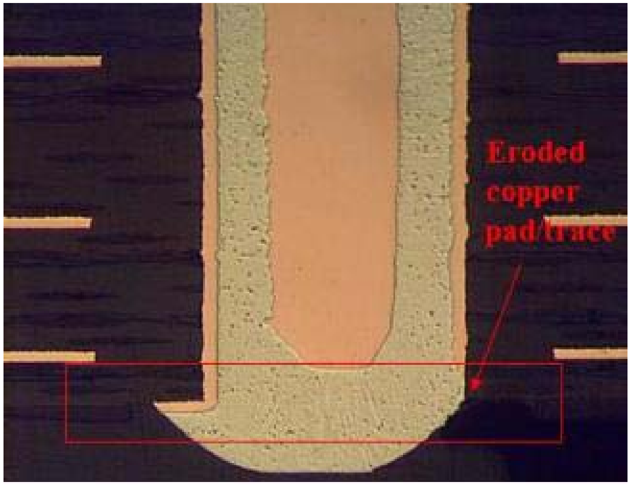

Figure 11: Cross-section of lead-free reworked PDIP components.

The time required for soldering and removing of SnPb parts with SnPb solder was much shorter than lead-free parts with SnAgCu solder indicating a better ability for the tin-lead solder to spread than SnAgCu which was partly related to the lower surface tension of the SnPb solder. The tin-lead solder gave better top side soldering than lead-free SnAgCu solder. A preheat setup would be required for SnAgCu rework to achieve similar results as SnPb rework, however, the use of a preheat stage was not typically common in a production environment which would necessitate equipment upgrades.

CONCLUSIONS

Mictor Connector Rework (Phase 1)

Due to the location of the Mictor connector relative to the bottom heaters (at the board edge), a non uniform temperature delta was monitored across the component solder joints.

When the board was cut in half (which could not be done in real life) and repositioned, a more uniform temperature delta was observed. Visual, x-ray and cross-section analysis was performed on the lead-free reworked Mictor connector revealing a good soldered bond.

More development was needed for better bottom-side heat distribution for rework machines especially on larger sized boards (12 x 18 inch).

The temperature on the board at 150mils away from the reworked tin-lead or lead-free components on 63mil and 135mil thick boards exceeded liquidus solder temperatures in all cases.

CBGA and uBGA Rework (Phase 2)

For the CBGA and uBGA rework, the board temperature (150mils away from rework component) was found to exceed the melting temperature of the soldering alloy for tin-lead and lead-free soldering.

A particular issue was also noted when reworking the uBGA256 near to the CBGA at location U27. The adjacent CBGA had undergone a partial double reflow which weakened its mechanical solder joint integrity. This needed to be understood more which was being investigated in an ongoing iNEMI rework optimization project.

There would be more need for higher temperature capability and better thermal controls for SnAgCu rework.

Bottom-side heat and thermal uniformity was critical to bring the board up to proper lead-free rework temperatures.

Rework equipment suppliers needed to develop their equipment more for higher temperature lead-free soldering with an emphasis on optimized rework profiles, and optimized machine tool sets.

Through-Hole PDIP Component Rework (Phase 2)

SnAgCu first pass wave soldering requires more dwell time and higher solder pot temperature in order to achieve similar results to SnPb first pass wave soldering. SnPb solder exhibited better capillary action on the leads and was able to spread itself better on the land pattern compared with SnAgCu solder partly as a result of its lower surface tension.

On second pass rework soldering, both alloys showed more difficulties in hole-fill and fillet forming. More dwell time was needed for both the alloys during rework.

SnPb soldering increased from 8 to 12 seconds in dwell time at the same temperature to achieve good solder fillets. Lead-free SnAgCu soldering increased from 20 to 30 seconds at the same temperature to achieve acceptable solder joint formation.

Increased temperatures and/or longer dwell time will encourage better hole-fill for SnAgCu but we need to ensure no board delamination and warpage, or component damage is caused due to the high temperatures and longer dwell times.

Copper barrel knee dissolution observed during the lead-free SnAgCu mini-pot rework from higher pot temperatures and dwell time was also a concern.

Preheating the board prior to lead-free soldering exhibited better soldering results and would be one area of investigation in the follow on iNEMI rework optimization study.

Improved hole-fill would be needed with SnAgCu solder with emphasis on development of the rework process on thicker boards such as 135mil thick.

ACKNOWLEDGEMENTS

The authors would like to gratefully thank all the participants of the NEMI lead-free assembly and rework project.

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