Creation of a Novel Pb-Free Water-Soluble Solder Paste that Improves Reliability Through Low Voiding and Ease of Washability

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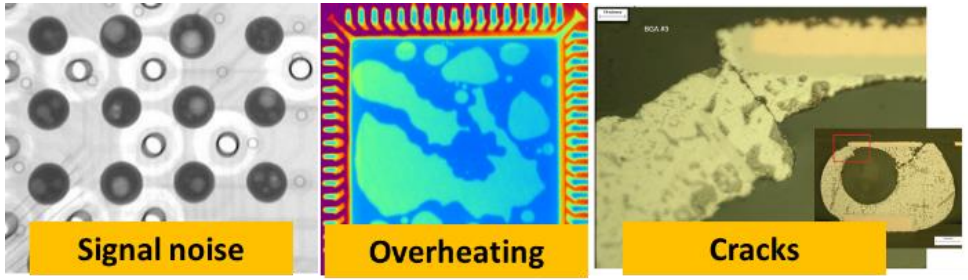
Outline/Agenda

- Introduction
  - Reliability Concerns
  - Water Soluble Pb-Free Solder Paste
- Experimental Setup
- Results
- Conclusions & Acknowledgements
- Q & A

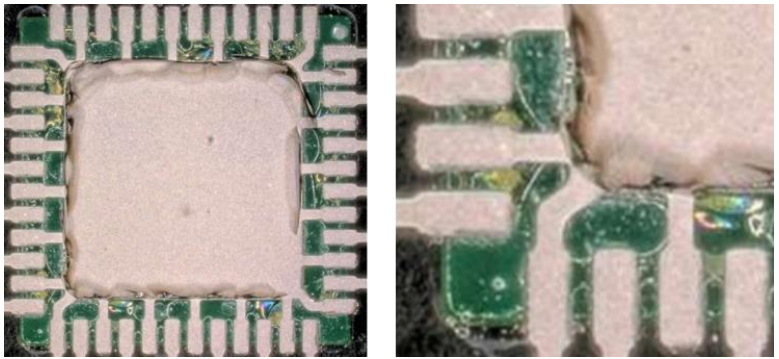
INTRODUCTION

Introduction - Reliability Concerns

Voids



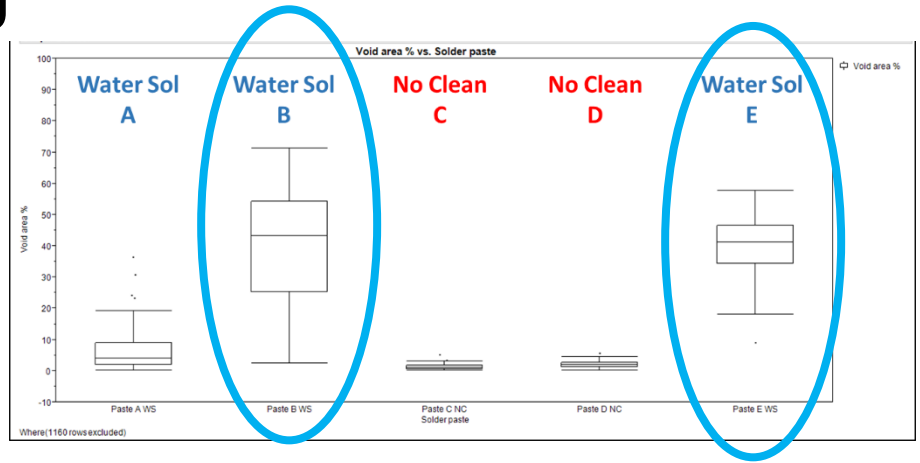
Flux residue



- Voiding in solder joints and un-washed flux residues pose reliability risks.

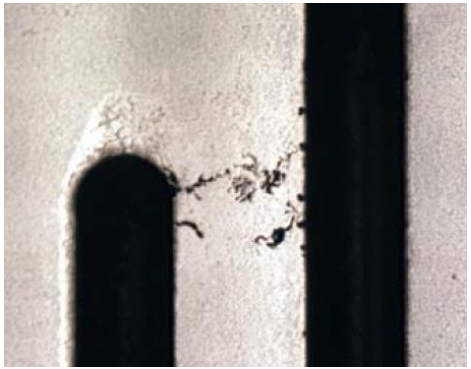
Introduction - Water Soluble Solder Paste

- Highly active (ionic species)
- Tend to absorb moisture
- Typically high in voiding



Introduction - Water Soluble Solder Paste

- Residues are corrosive and conductive
- Hard to remove under low-standoff components
- Can lead to dendritic growth



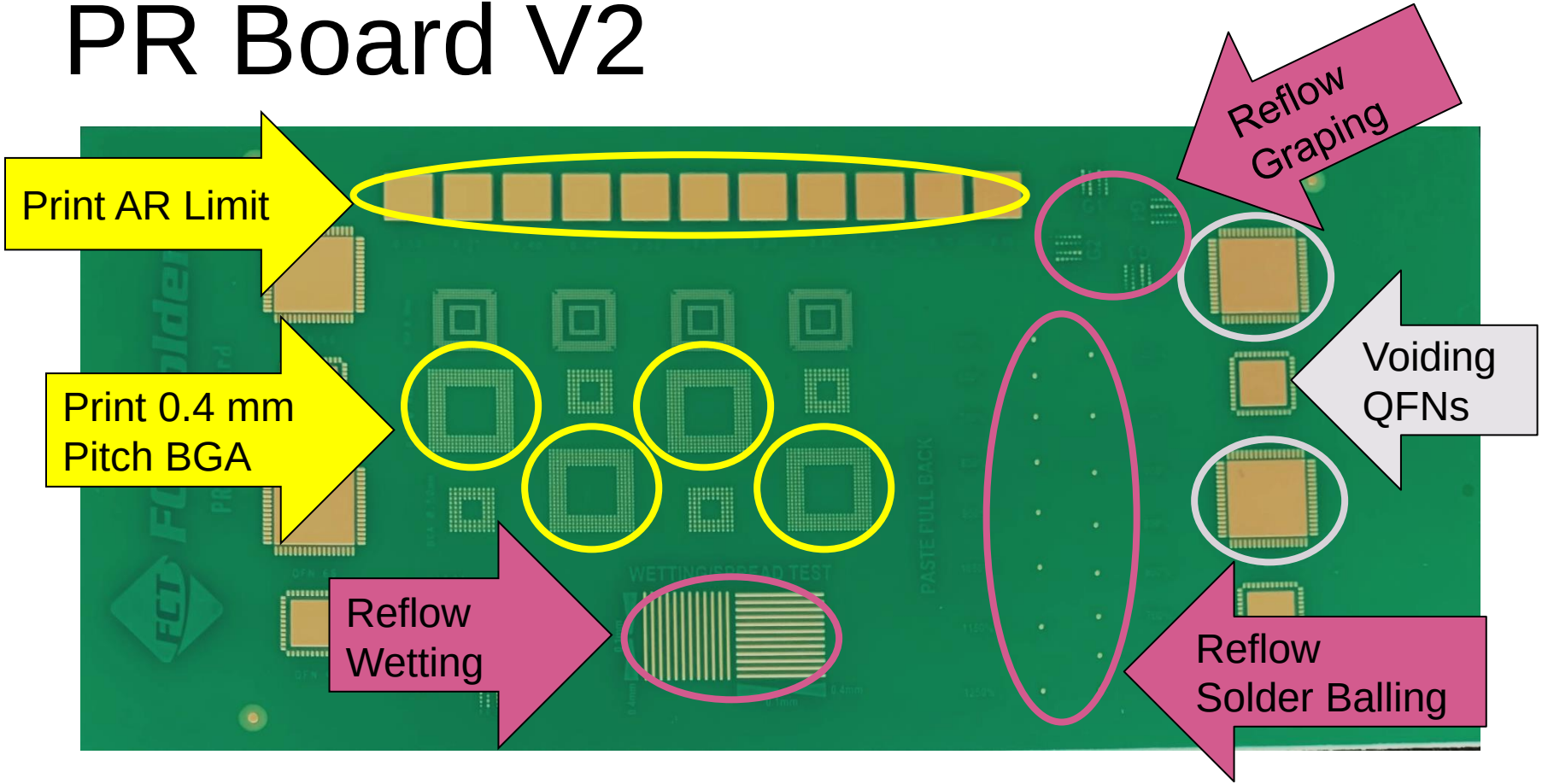
Need a new water soluble solder paste
- Low voiding
- Easy to wash
- High reliability

EXPERIMENTAL SETUP

Experimental Setup

- Two experiments for new WS solder paste
  - General solder paste performance
    - Compared to the current technology
  - Cleaning and reliability of flux residues
    - Cleaning in DI water and engineered chemistry
    - SIR testing under low-standoff components

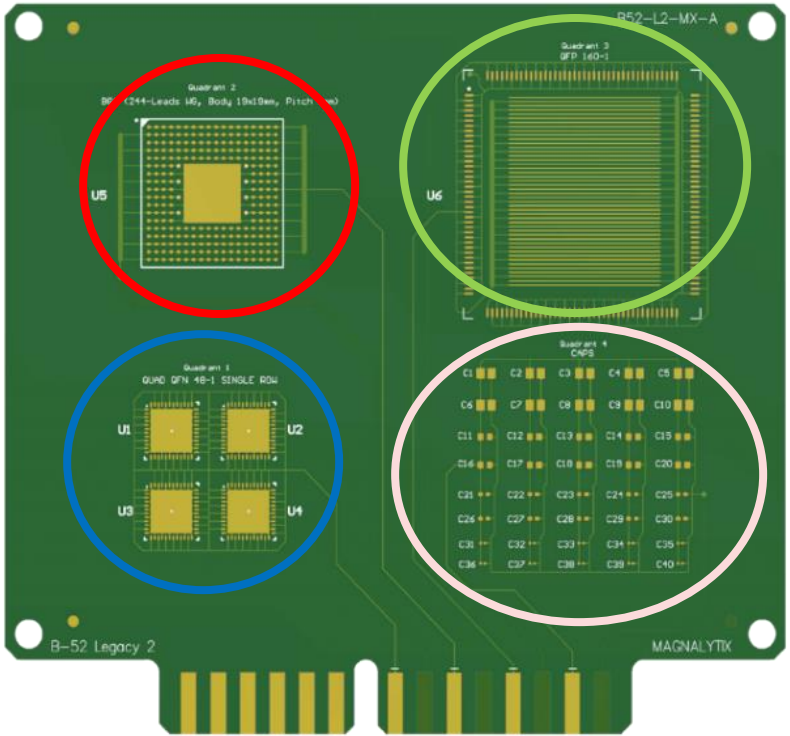
PR Board V2


Print AR Limit
Print 0.4 mm Pitch BGA
Reflow Wetting
Reflow Graping
Voiding QFNs
Reflow Solder Balling

PR Board V2 & General Paste Performance

- Tack force change over time
- Moisture absorption
- Stencil life over 8 hr print and pause
- Wetting on OSP and ENIG
- Voiding in QFN thermal pads
  - Linear-RTS and Soak-RSS profiles

IPC B-52 Legacy 2



4 Quadrants

QFN-48 (4x): 0.5 mm pitch

- Standoff = 20-40 µm

BGA-244 with center lug: 1.0 mm pitch

- Standoff = 80-120 µm

QFP-160: 0.65 mm pitch with an SIR Comb

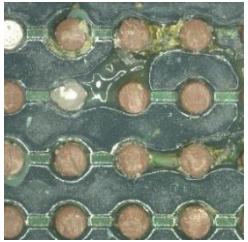
- Detects wash fluid entrapment
- Standoff = 30-40 µm

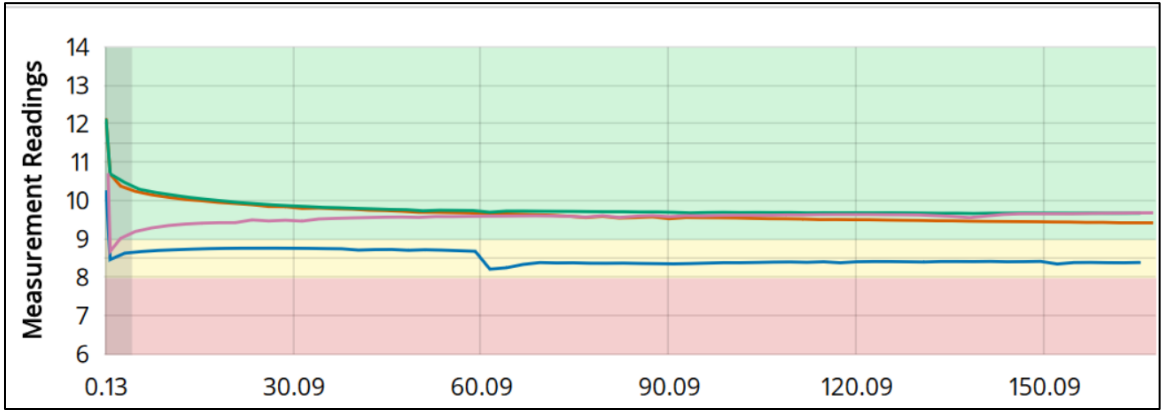
Passive capacitors (10x each): 0805, 0603, 0402, & 0201 Imperial sizes

- Standoff = <50 µm

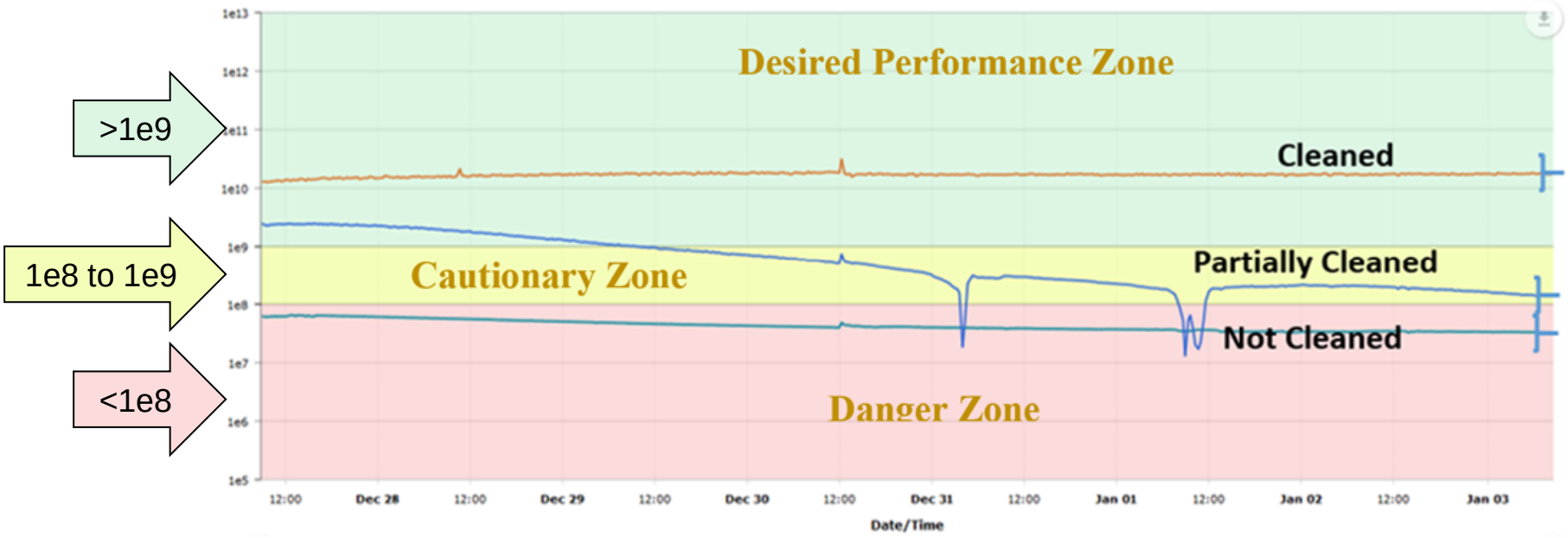
IPC B-52 Legacy 2 Measures

- Cleanliness under low standoff components
- SIR values from 4 quadrants
  - Blue = QFN
  - Red = BGA
  - Green = QFP
  - Pink = Caps



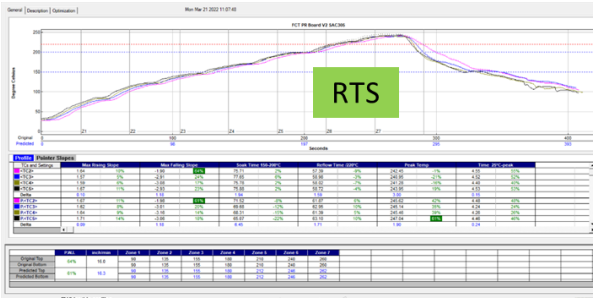


SIR Requirements



Test Variables

- Two solder pastes
  - WS#1 = Legacy product
  - WS#2 = New product
- Two reflow profiles
  - Ramp-to-spike (RTS)
  - Ramp-soak-spike (RSS)
- Two cleaning methods
  - Inline with DI water
  - Inline with Engineered aq. chemistry



Test Matrix

Test #	Test Board	Solder Paste #1	Solder Paste #2	Solder Profile Ramp to Spike	Solder Profile Soak Profile	Inline - DI Water	Inline - Eng. Aq.	SIR [40°C/90% RH/ 5V / 168-Hours]
		WS #1		x		No-Clean	No-Clean	x
1	MGX B52 Legacy 2	WS #1		x		x		x
2	MGX B52 Legacy 2	WS #1		x		x		x
3	MGX B52 Legacy 2	WS #1		x			x	x
4	MGX B52 Legacy 2	WS #1		x			x	x
		WS #1			x	No-Clean	No-Clean	x
5	MGX B52 Legacy 2	WS #1			x	x		x
6	MGX B52 Legacy 2	WS #1			x	x		x
7	MGX B52 Legacy 2	WS #1			x		x	x
8	MGX B52 Legacy 2	WS #1			x		x	x
			WS#2	x		No-Clean	No-Clean	x
1	MGX B52 Legacy 2		WS#2	x		x		x
2	MGX B52 Legacy 2		WS#2	x		x		x
3	MGX B52 Legacy 2		WS#2	x			x	x
4	MGX B52 Legacy 2		WS#2	x			x	x
			WS#2		x	No-Clean	No-Clean	x
5	MGX B52 Legacy 2		WS#2		x	x		x
6	MGX B52 Legacy 2		WS#2		x	x		x
7	MGX B52 Legacy 2		WS#2		x		x	x
8	MGX B52 Legacy 2		WS#2		x		x	x

SIR test

Test Parameters

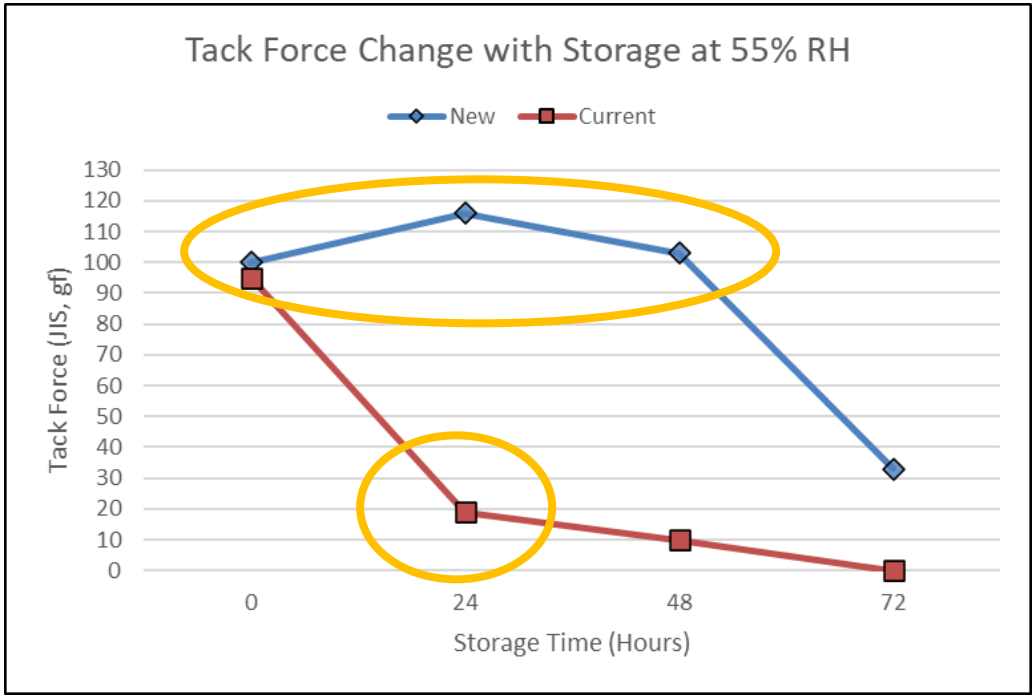
Print Parameter	Value
Print speed (mm/sec)	25 mm/sec
Blade length (mm)	305 mm
Print pressure (kg)	6.8 kg
Separation speed (mm/sec)	1 mm/sec
Separation distance (mm)	1 mm
Stencil thickness (µm)	100 microns
Stencil material	Stainless steel with nano-coating

Reflow Parameter	Ramp-to-Spike (RTS)	Ramp-Soak-Spike (RSS)
Time above 220 °C	57-59 sec	60-67 sec
Time between 150-200 °C	75-78 sec	104-112 sec
Peak temperature	241-244 °C	243-246 °C
Time 25 °C to peak temperature	4.4-4.6 min	5.4-5.5 min

Cleaning Parameter	Value
Cleaning process	In-line
Belt speed (m/min)	1.0 ft./minute
Wash temperature (°C)	60°C
Wash chemistry & concentration (% vol)	DI-Water & Eng. Aqueous diluted in DI-Water at 5%
Rinse temperature (°C)	54°C
Dry temperature (°C)	48°C

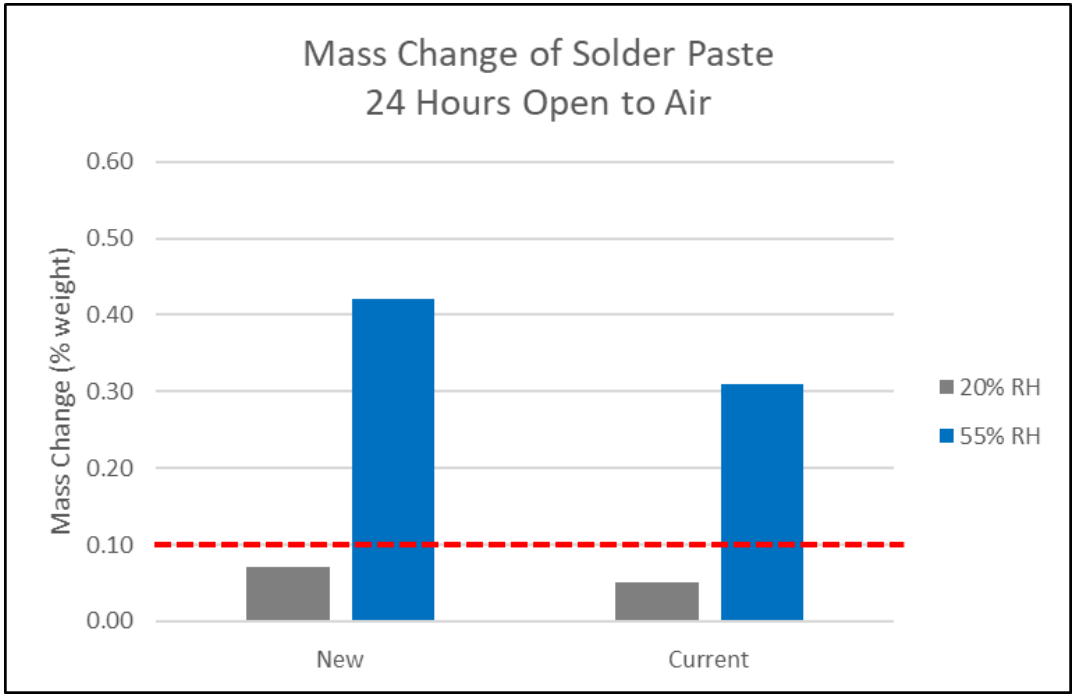
RESULTS: GENERAL PERFORMANCE

General Solder Paste Performance



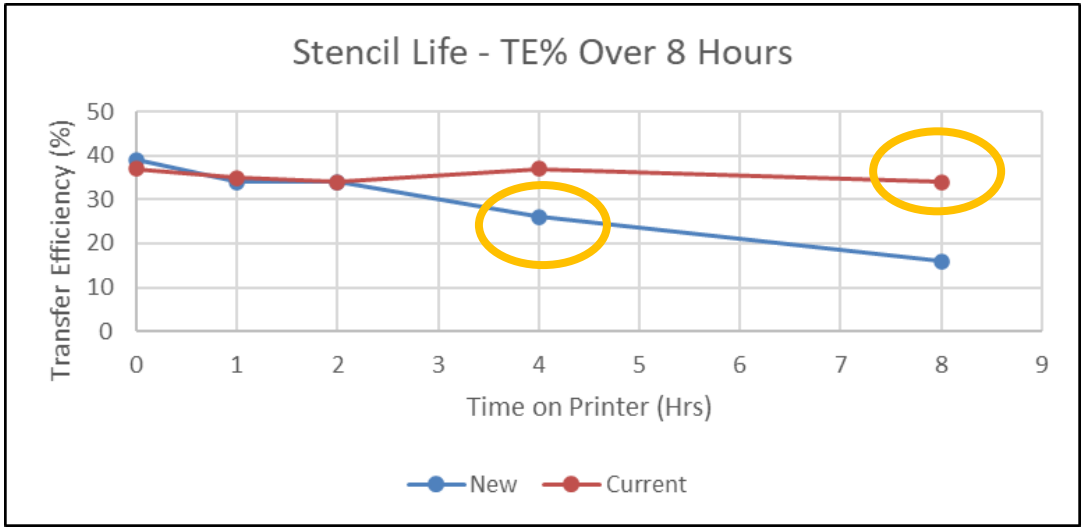
- Current paste looses tack force over 24 hours
- New paste maintains tack over 48 hours

General Solder Paste Performance



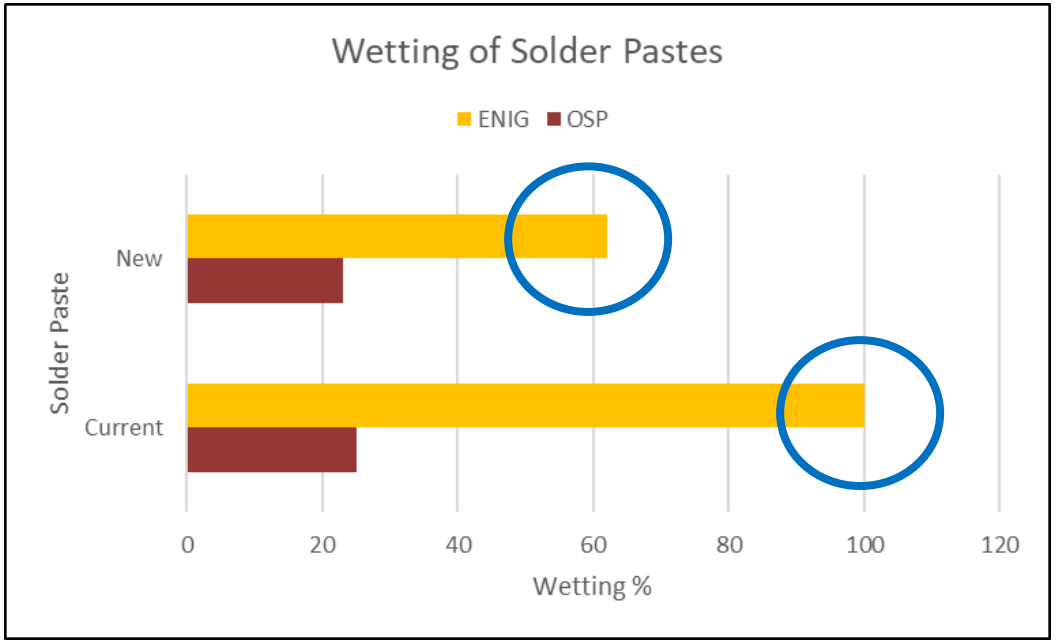
- Current solder paste is slightly less hygroscopic than the new paste

General Solder Paste Performance



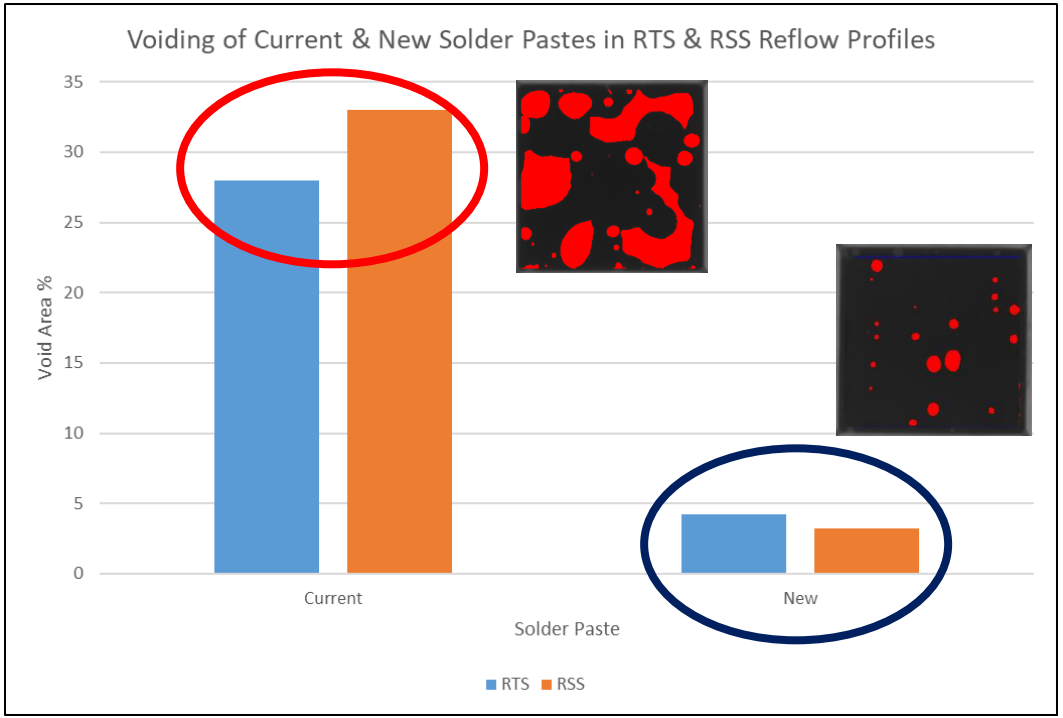
- Current solder paste is printable over 8 hours
- New solder paste is printable longer than 4 hours

PR Board V2 Performance



- Current solder spreads farther on ENIG than the new paste
- Both wet ENIG & OSP acceptably

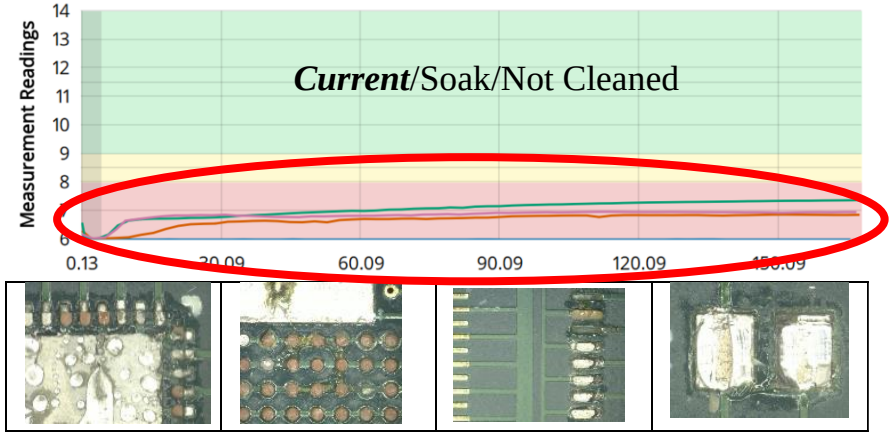
PR Board V2 Performance



- Current solder paste tends to give high voiding
- New solder paste gives “ultra low voiding”

RESULTS: CLEANING & SIR PERFORMANCE

B-52 Legacy 2 Board Performance

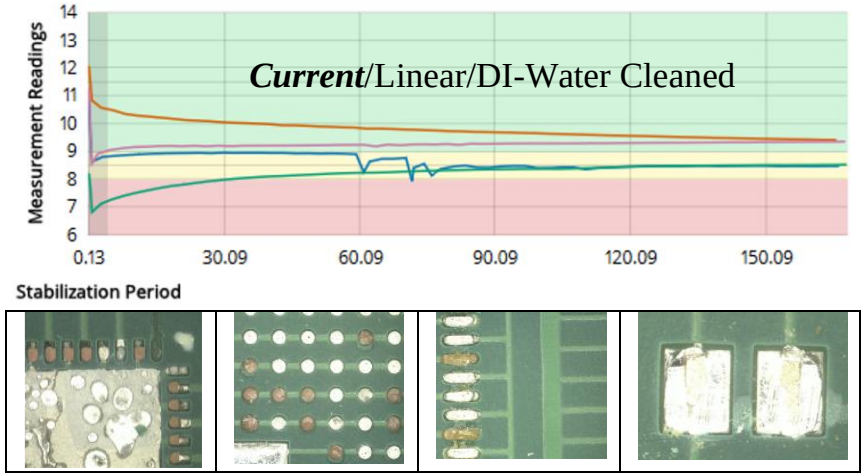


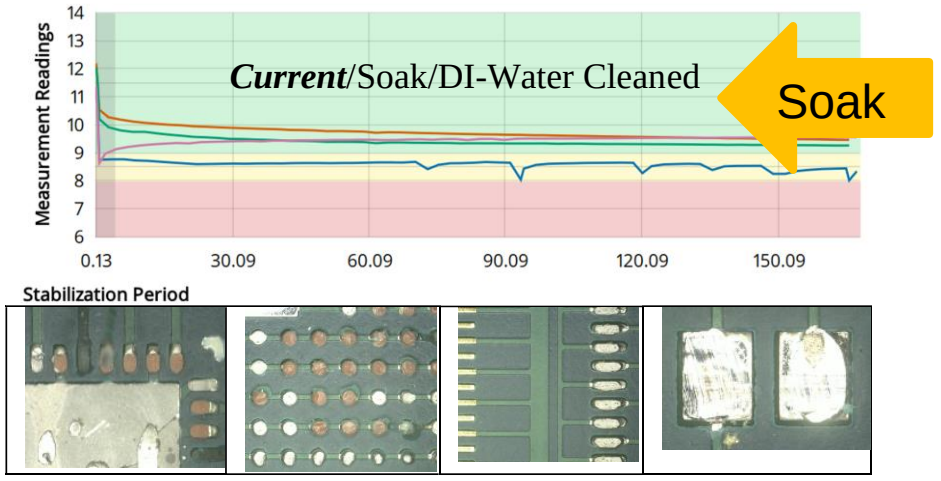
Current/Soak/Not Cleaned

New/Soak/Not Cleaned

- The current & new solder pastes fail SIR when not cleaned, as expected

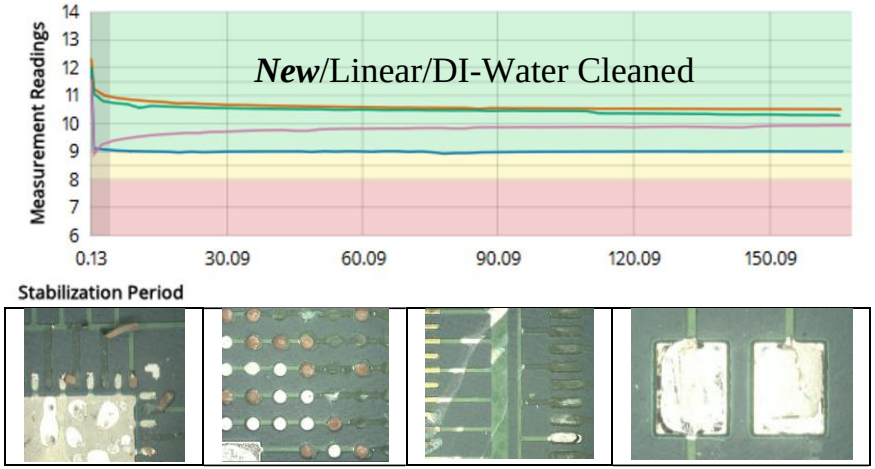
B-52 Legacy 2 Board Performance

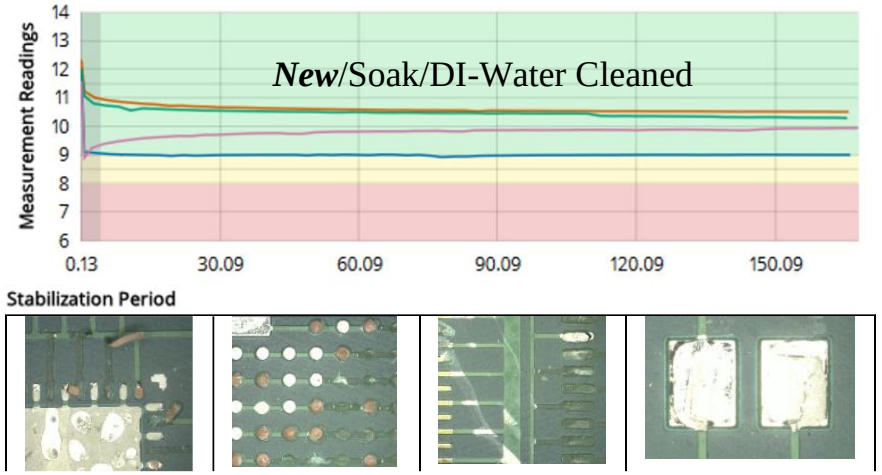




- The soak profile resulted in improved cleaning of the current solder paste

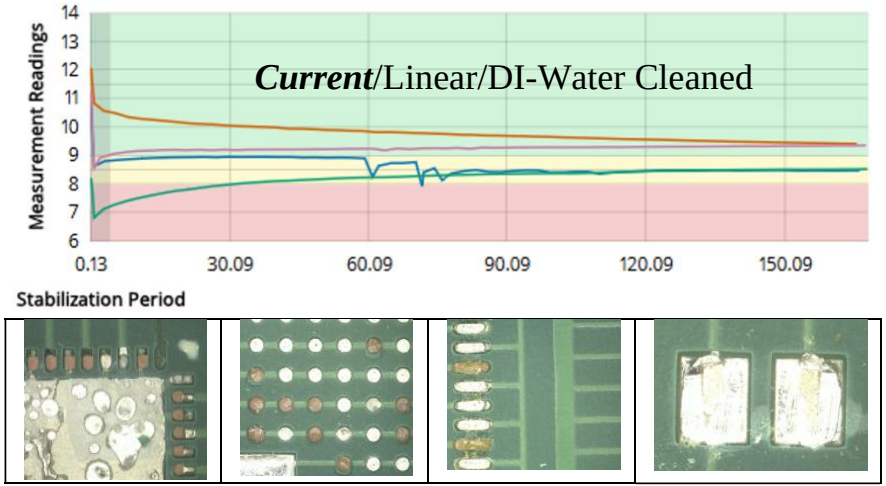
B-52 Legacy 2 Board Performance

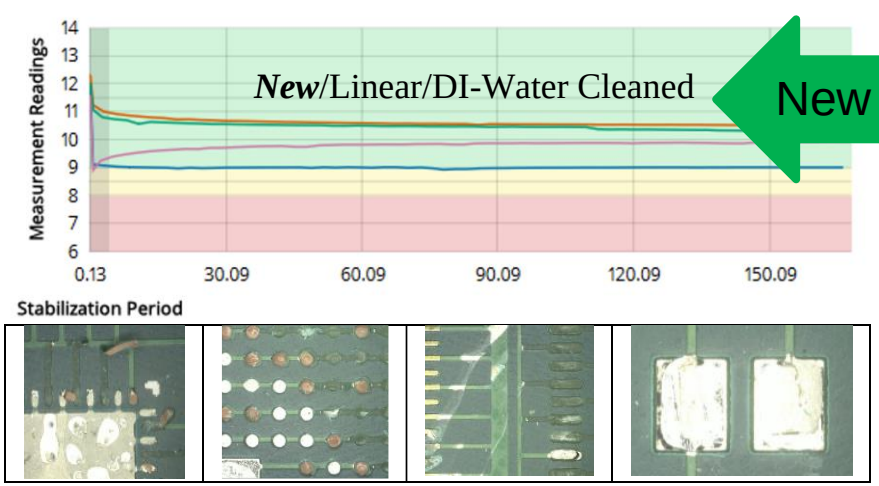




- The new solder paste cleaned well after both reflow profiles

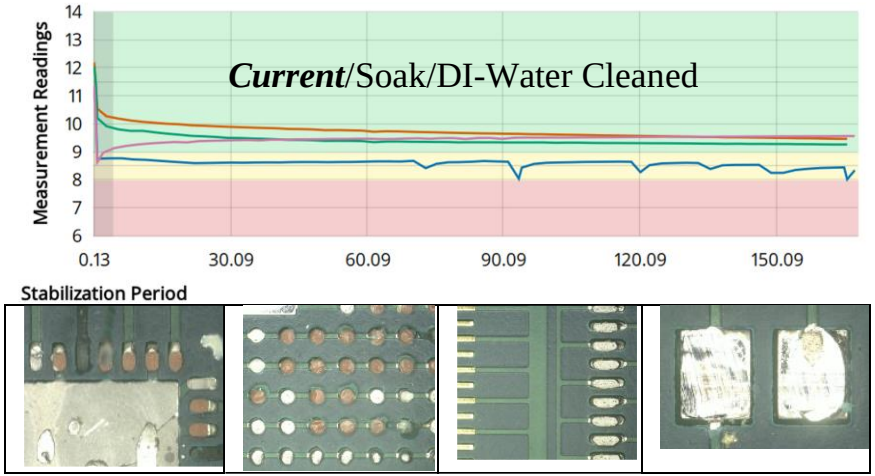
B-52 Legacy 2 Board Performance

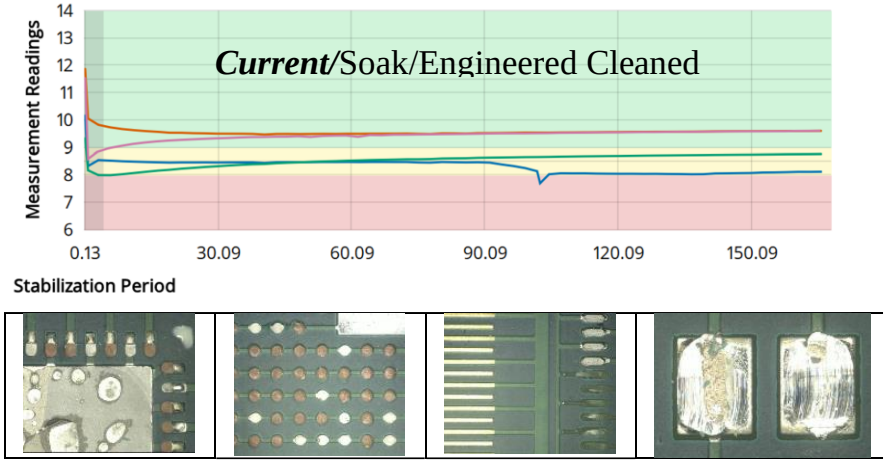




- The new solder paste cleaned better than the current paste

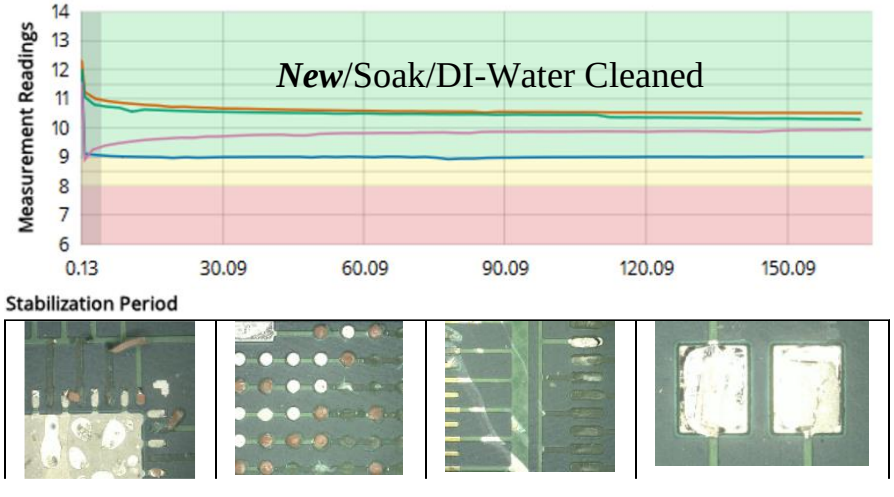
B-52 Legacy 2 Board Performance

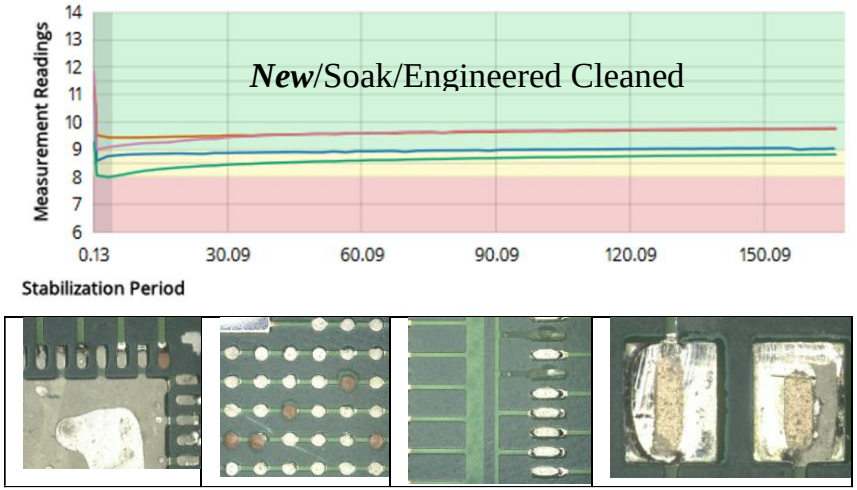




- Cleaning of the current solder paste was comparable with DI water & the engineered agent

B-52 Legacy 2 Board Performance





- Cleaning of the new solder paste was comparable with DI water & the engineered agent

Reliability of Flux Residues - Min SIR

Test #	Test Board	Solder Paste #1	Solder Paste #2	Solder Profile Ramp to Spike	Solder Profile Soak Profile	Inline - DI Water	Inline - Eng. Aq.	SIR [40°C/90% RH/ 5V / 168-Hours]	QFN-48 05 mm pitch	FCBA with a Center Lug 1.0 mm pitch	QFP-160 0.65 mm pitch	Net of Caps
		WS #1		x		No-Clean	No-Clean	x	6.00 $Log_{10}\Omega$	7.06 $Log_{10}\Omega$	7.34 $Log_{10}\Omega$	6.93 $Log_{10}\Omega$
1	MGX B52 Legacy 2	WS #1		x		x		x	8.49 $Log_{10}\Omega$	9.42 $Log_{10}\Omega$	8.54 $Log_{10}\Omega$	9.37 $Log_{10}\Omega$
2	MGX B52 Legacy 2	WS #1		x		x		x	8.95 $Log_{10}\Omega$	9.06 $Log_{10}\Omega$	8.54 $Log_{10}\Omega$	9.55 $Log_{10}\Omega$
3	MGX B52 Legacy 2	WS #1		x			x	x	8.21 $Log_{10}\Omega$	9.38 $Log_{10}\Omega$	9.02 $Log_{10}\Omega$	9.55 $Log_{10}\Omega$
4	MGX B52 Legacy 2	WS #1		x			x	x	7.76 $Log_{10}\Omega$	9.46 $Log_{10}\Omega$	9.32 $Log_{10}\Omega$	9.59 $Log_{10}\Omega$
		WS #1			x	No-Clean	No-Clean	x	6.00 $Log_{10}\Omega$	6.87 $Log_{10}\Omega$	7.38 $Log_{10}\Omega$	6.96 $Log_{10}\Omega$
5	MGX B52 Legacy 2	WS #1			x	x		x	8.37 $Log_{10}\Omega$	9.48 $Log_{10}\Omega$	9.29 $Log_{10}\Omega$	9.58 $Log_{10}\Omega$
6	MGX B52 Legacy 2	WS #1			x	x		x	8.40 $Log_{10}\Omega$	9.44 $Log_{10}\Omega$	9.68 $Log_{10}\Omega$	9.69 $Log_{10}\Omega$
7	MGX B52 Legacy 2	WS #1			x		x	x	8.14 $Log_{10}\Omega$	9.62 $Log_{10}\Omega$	8.78 $Log_{10}\Omega$	9.62 $Log_{10}\Omega$
8	MGX B52 Legacy 2	WS #1			x		x	x	8.07 $Log_{10}\Omega$	9.55 $Log_{10}\Omega$	8.76 $Log_{10}\Omega$	9.59 $Log_{10}\Omega$
			WS#2	x		No-Clean	No-Clean	x	6.00 $Log_{10}\Omega$	6.70 $Log_{10}\Omega$	7.28 $Log_{10}\Omega$	6.70 $Log_{10}\Omega$
1	MGX B52 Legacy 2		WS#2	x		x		x	9.02 $Log_{10}\Omega$	10.53 $Log_{10}\Omega$	10.30 $Log_{10}\Omega$	9.95 $Log_{10}\Omega$
2	MGX B52 Legacy 2		WS#2	x		x		x	9.04 $Log_{10}\Omega$	10.79 $Log_{10}\Omega$	10.00 $Log_{10}\Omega$	9.87 $Log_{10}\Omega$
3	MGX B52 Legacy 2		WS#2	x			x	x	9.13 $Log_{10}\Omega$	10.06 $Log_{10}\Omega$	8.80 $Log_{10}\Omega$	9.87 $Log_{10}\Omega$
4	MGX B52 Legacy 2		WS#2	x			x	x	9.10 $Log_{10}\Omega$	10.07 $Log_{10}\Omega$	9.31 $Log_{10}\Omega$	9.87 $Log_{10}\Omega$
			WS#2		x	No-Clean	No-Clean	x	6.27 $Log_{10}\Omega$	6.57 $Log_{10}\Omega$	7.17 $Log_{10}\Omega$	6.65 $Log_{10}\Omega$
5	MGX B52 Legacy 2		WS#2		x	x		x	9.04 $Log_{10}\Omega$	10.82 $Log_{10}\Omega$	10.26 $Log_{10}\Omega$	9.95 $Log_{10}\Omega$
6	MGX B52 Legacy 2		WS#2		x	x		x	9.02 $Log_{10}\Omega$	10.63 $Log_{10}\Omega$	10.27 $Log_{10}\Omega$	9.91 $Log_{10}\Omega$
7	MGX B52 Legacy 2		WS#2		x		x	x	9.04 $Log_{10}\Omega$	9.84 $Log_{10}\Omega$	8.83 $Log_{10}\Omega$	9.75 $Log_{10}\Omega$
8	MGX B52 Legacy 2		WS#2		x		x	x	9.06 $Log_{10}\Omega$	9.76 $Log_{10}\Omega$	8.84 $Log_{10}\Omega$	9.81 $Log_{10}\Omega$

- The new solder paste has overall higher SIR

CONCLUSIONS & ACKNOWLEDGEMENTS

Conclusions

- The new solder paste improves tack time, and gives ultra-low voiding
- Water soluble (OA) solder paste residues cause reliability concerns
  - The new solder paste is easier to clean and more reliable than the current technology
  - Cleaning with the engineered agent was comparable to DI water, and enables cleaning in tight spaces

Acknowledgements

- We thank Mark McMeen and STI for their assistance with this project.

Thank You!

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