Engineering Manual

Innolot LF318 Solder Paste

March 2010

Introduction

About the Electronics Group of Henkel

- Henkel is the world’s leading & most progressive provider of qualified, compatible material sets for semiconductor packaging, board level assembly & advanced soldering solutions. Through its Hysol®, Loctite® and Multicore® brands and its global customer support infrastructure, Henkel delivers world-class materials products, process expertise and total solutions across the board to pre-empt industry changes. By partnering with key industry leaders to pioneer added value materials and processes, and by prioritizing environmental responsibility and training, Henkel is formulating the materials to enable tomorrow’s electronics industry.

Introduction

Product Description

- Henkel's Multicore™ Innolot LF318 solder paste is a halide-free, no clean, pin testable solder paste.
- The utilisation of the novel Innolot alloy provides a material with improved reliability in thermal cycle/thermal shock testing without compromising the overall excellent process capabilty of the solder paste.
- The ability to produce Innolot alloy with identical particle size distributions to standard SAC alloys, additionally the very similar alloy densities allows for a direct drop-in to the printing process.
- The close proximity of the melting range of Innolot alloys when compared to standard SAC based materials has minimum impact on the reflow process.

Introduction

Innolot LF318 Features & Benefits

Product Attribute	Process Benefit
Novel senary element alloy	Significantly improved final product reliability at higher temperature thermal shock or thermal cycle testing when compared to standard SAC alloys
Outstanding humidity resistance – excellent coalescence after 8 hours exposure to 27°C/80%RH	Reduced process variation due to environmental factors, a particular advantage in high temperature/humidity conditions
Colourless residues	Improves speed & ease of post reflow inspection
Soft, non-stick pin testable residues	Improves ease and reliability of in-circuit testing and reduces frequency with which test probes require cleaning
Long open and abandon time capability (4 hours on 0.5mm CSP at 22°C, 40%RH)	Minimises paste wastage
Excellent stability when printed at high temperatures & humidity and high temperature low humidity	Maintains process consistency
Colourless residues	Improves speed & ease of post reflow inspection
Low voiding	Reduced risk of bridging on small pitch CSPs & BGAs. Reduced risk of decreased joint reliability
Halide free flux classification: ROL0	High reliability of finished assembly without cleaning

Physical Properties

Technical Data

Datasheet Innolot LF318

Operating Parameters

Printing: Process window

- **Innolot LF318 solder paste was subjected to testing in Henkel laboratories to establish the print process window, using the following equipment**

Printer	DEK260
Stencil	Laser cut, stainless steel, 125μm (approx. 0.005”) thickness
Boards	Bare copper, no resist
Deposits Examined	0.64mm (approx. 0.025”) QFP100 (0.38mm (approx 0.015”) pads), 0.5mm (approx. 0.020”) TQFP100 (0.25mm (approx. 0.010”) pads), 0.4mm (approx. 0.016”) TQFP (0.2mm (approx. 0.008”) pads) and BGA225 (1.27mm (approx. 0.050”) pitch)
Inspection	Stereomicroscope (x10-x30)

- **Ambient conditions during testing were 24°C/28%RH**
- **A solder paste bead of approximately 250g was placed on the stencil and printed onto the boards at speeds ranging from 20 to 200mm/s and squeegee pressures ranging from 2-8kg (approx. 4.4 – 17.6lbs). Stroke was set at 230mm (approx. 9”), separation speed at 10% and the print gap at zero (contact print).**
- **During printing, paste roll, stencil wipe, aperture release and drop-off where assessed with the naked eye. After printing, the solder paste deposits were examined using a stereomicroscope to assess the general appearance and note any defects.**

Operating Parameters

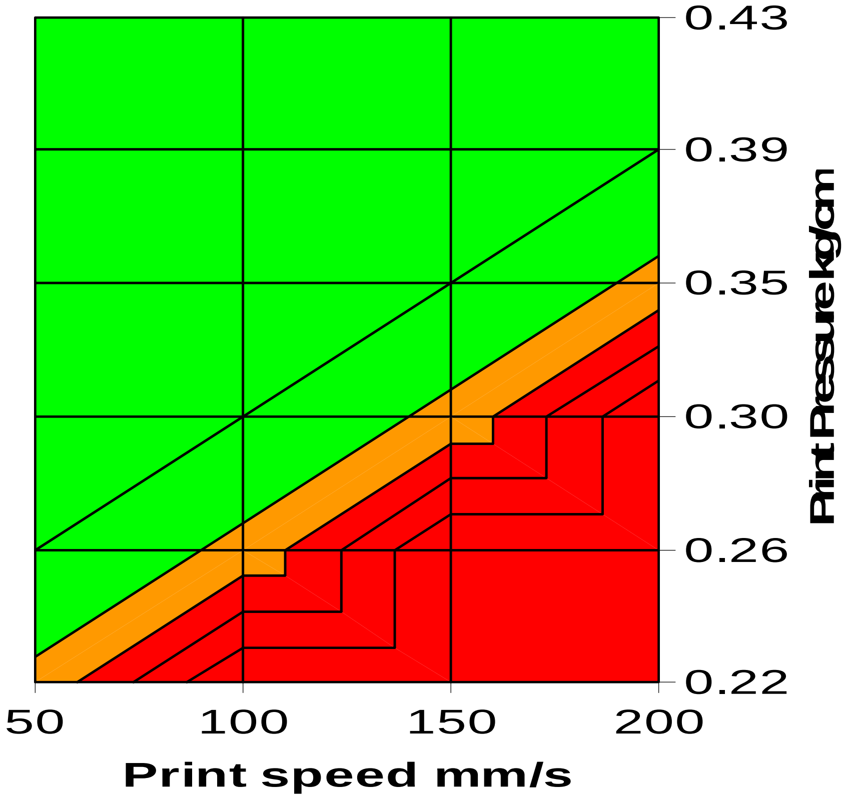
Printing: Process window

- **Printing defects were categorised into the following classifications, severity of defect was noted and graded to allow subtle changes to be detected and recorded**

Topography/Volume consistency	Ideally the shape and volume of the paste deposit should reflect the stencil aperture geometry. The top surface and sides should be smooth with no irregularities
Skipping	Little or no evidence of printed paste on the pad due to non-filling of stencil apertures or non-release of paste from apertures
Incomplete or insufficient fill	Poor paste coverage of the pads due to paste not being completely released from the stencil or apertures not being completely filled during the printing process
Spikes	Central areas of the printed deposit raised, usually attributable to excessively low print pressure (or high print speed)
Dog-ears	Extremities of the paste deposit raised, usually attributable to poor release from the aperture

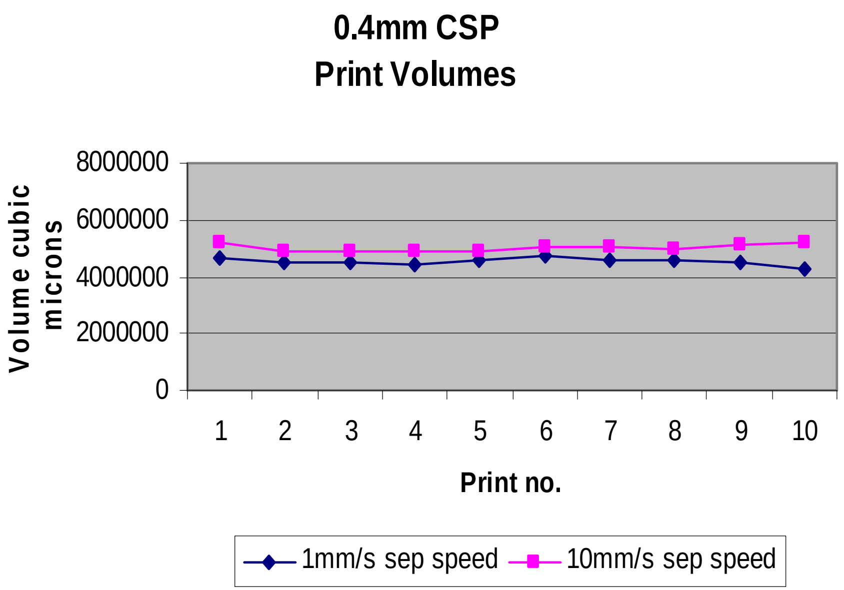
Operating Parameters

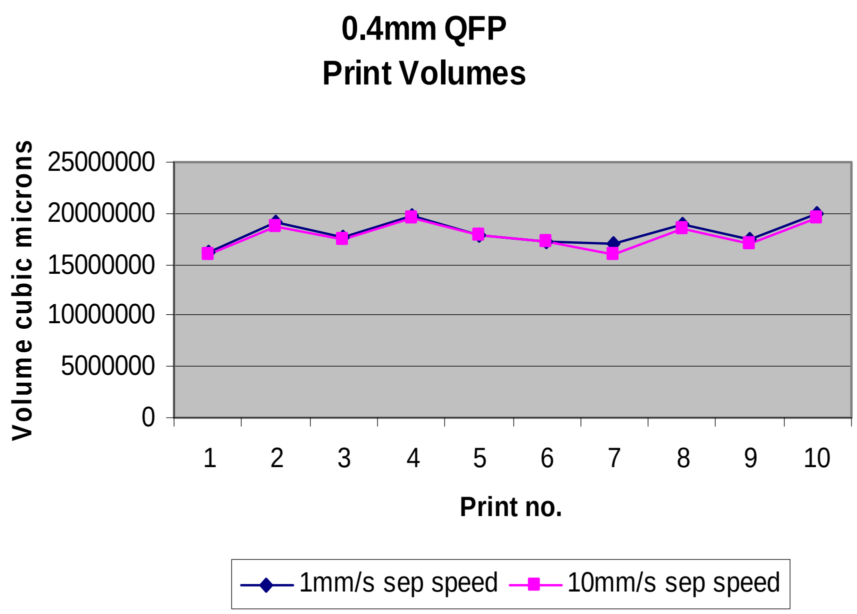
Printing: Process window, type 3 (AGS)



Operating Parameters

Printing: Separation Speed





- **Faster separation speed for improved volume on smaller components**

Operating Parameters

Printing: Slump Test

- **In-house testing**
- **Innolot LF318 solder paste was subjected to slump testing in the Henkel laboratories in accordance with IPC™-650-2.4.35 using a 0.2mm (approx. 0.008”) thick stencil, IPC™ slump pattern A-21.**

Initial 0.63 x 2.03mm pads

Spacing/ mm	Horizontal				Vertical			
0.79	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.71	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.63	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.56	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.48	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.41	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.33	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Slump after 15mins at Room Temperature 0.63 x 2.03mm pads

Spacing/ mm	Horizontal				Vertical			
0.79	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.71	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.63	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.56	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.48	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.41	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.33	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Slump after 15minutes at 150C 0.63 x 2.03mm pads

Spacing/ mm	Horizontal				Vertical			
0.79	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.71	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.63	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.56	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.48	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.41	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.33	Bridge	Bridge	Bridge	Pass	Bridge	Pass	Bridge	Pass

Operating Parameters

Printing: Slump Test

- **In-house testing**
- **Innolot LF318 solder paste was subjected to slump testing in the Henkel laboratories in accordance with IPC™-650-2.4.35 using a 0.2mm (approx. 0.008”) thick stencil, IPC™ slump pattern A-21.**

Initial 0.33 x 2.03mm pads								
Spacing/ mm	Horizontal				Vertical			
0.79	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.71	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.63	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.56	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.48	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.41	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.33	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Slump after 15mins at Room Temperature 0.33 x 2.03mm pads								
Spacing/ mm	Horizontal				Vertical			
0.79	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.71	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.63	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.56	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.48	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.41	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.33	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Slump after 15minutes at 150C 0.33 x 2.03mm pads								
Spacing/ mm	Horizontal				Vertical			
0.79	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.71	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.63	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
0.56	Pass	Bridge	Bridge	Bridge	Pass	Pass	Bridge	Bridge
0.48	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge
0.41	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge
0.33	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge	Bridge

Operating Parameters

Printing: Slump Test

- **IPC ANSI/J-STD-005 Slump Test**

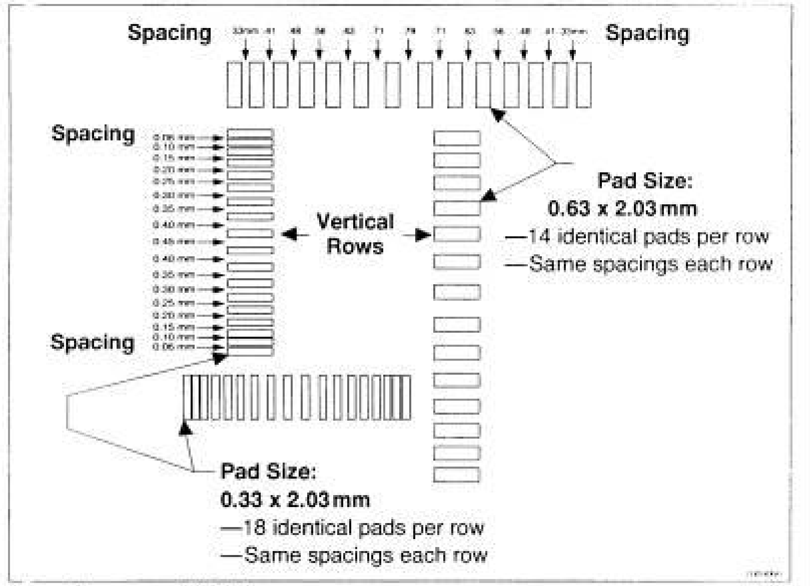
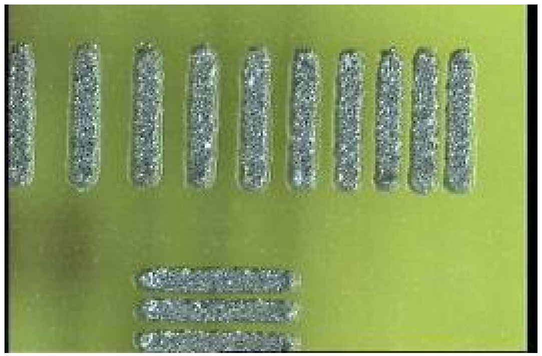
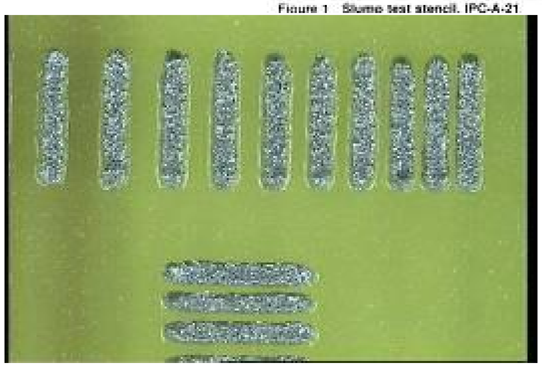


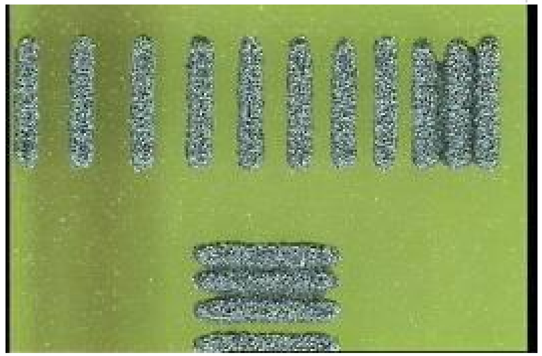
Figure 1 Slump test stencil, IPC-A-21



As printed



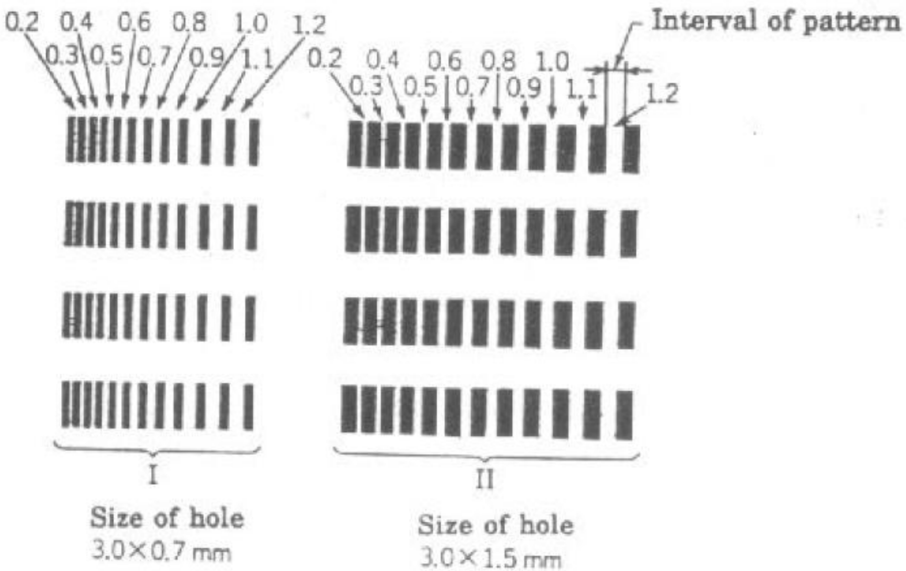
15minutes RT

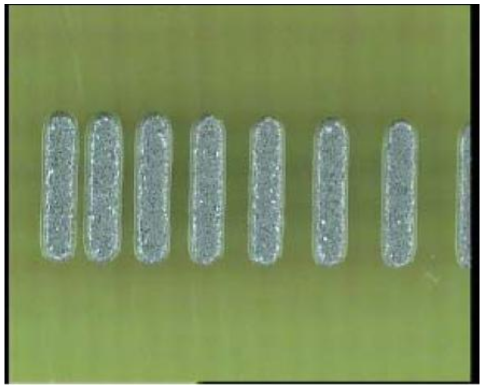


15minutes 150C

Operating Parameters
Printing: Slump Test

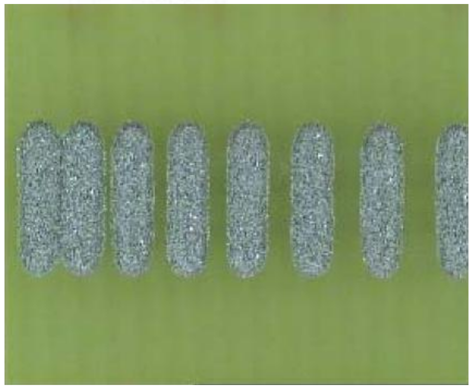
- **JIS-Z-3284 Slump Test**





15minutes RT

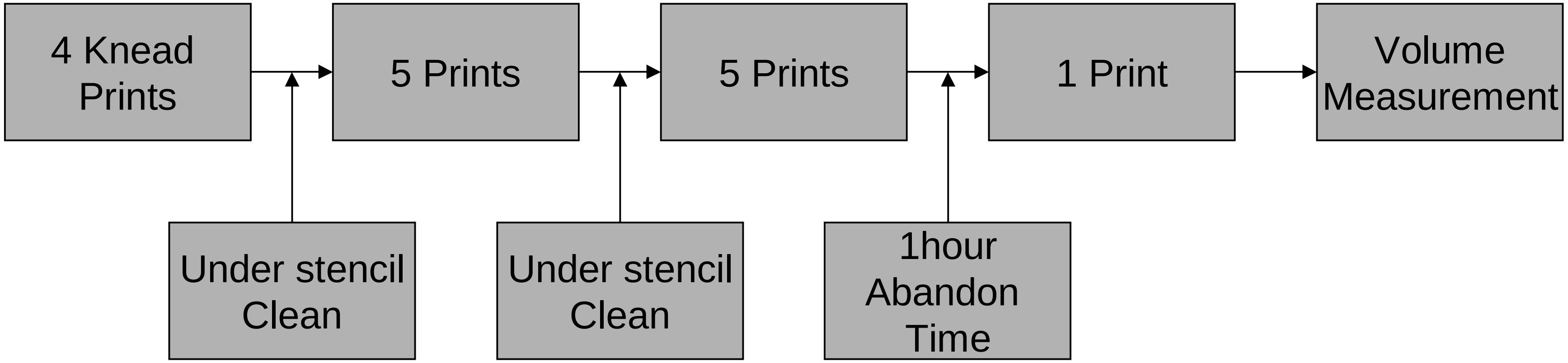
1minute 150C



15minutes 150C

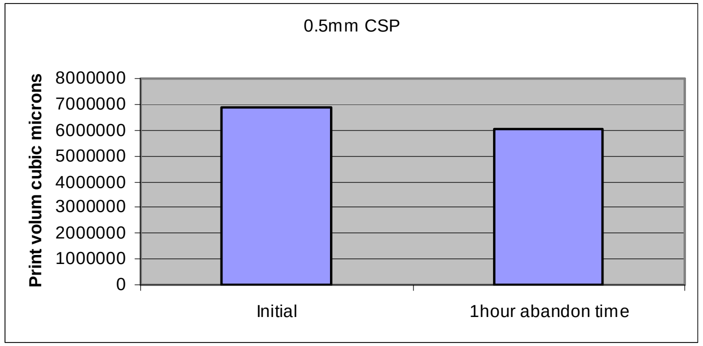
Printing: Abandon Time

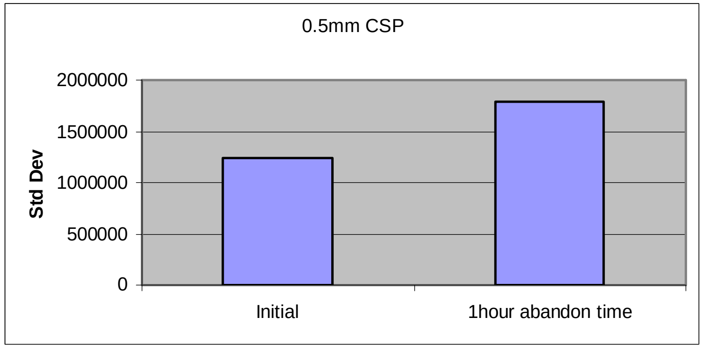
- **Response to 1hour pause**

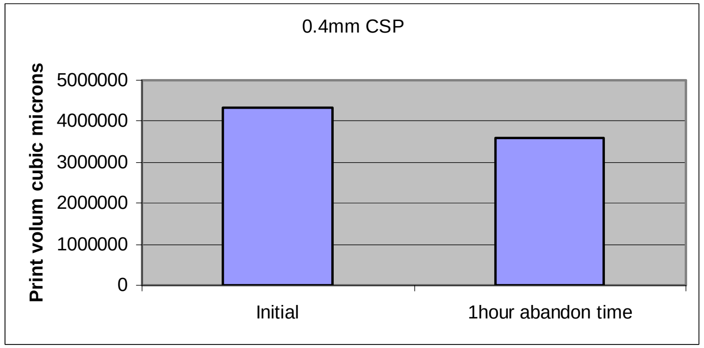


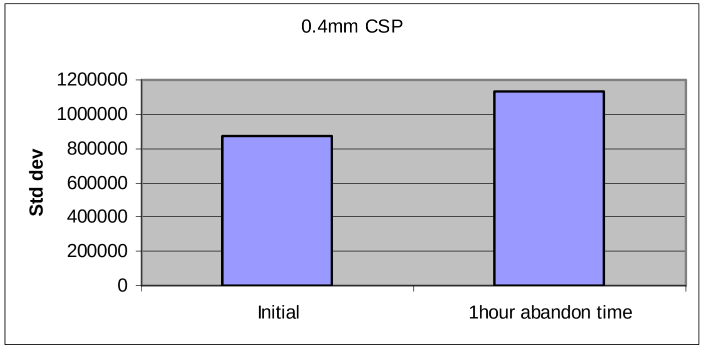
Operating Parameters

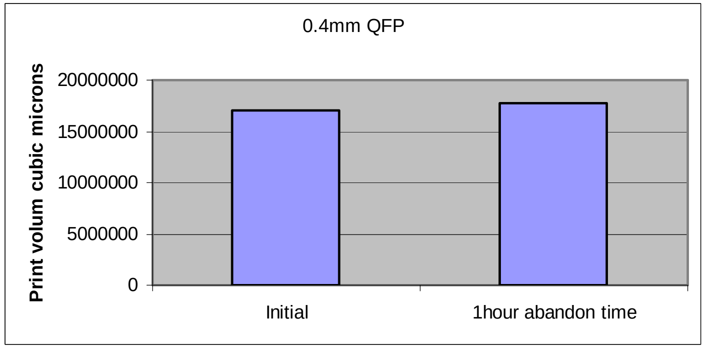
Printing: Abandon Time

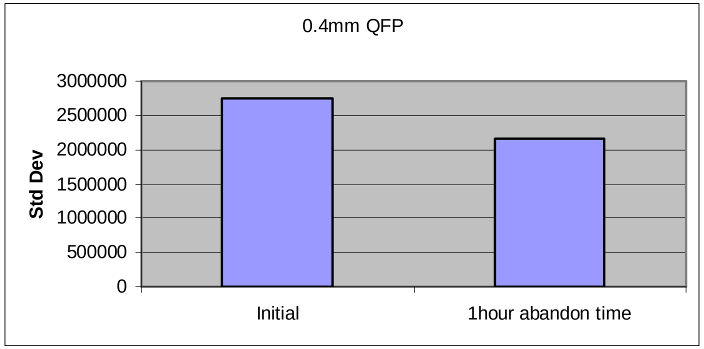








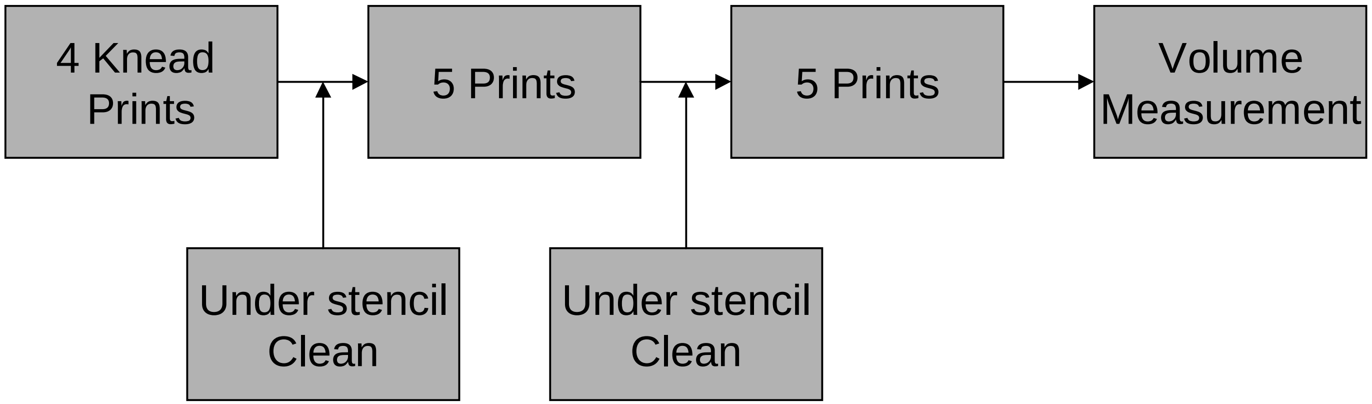




Operating Parameters

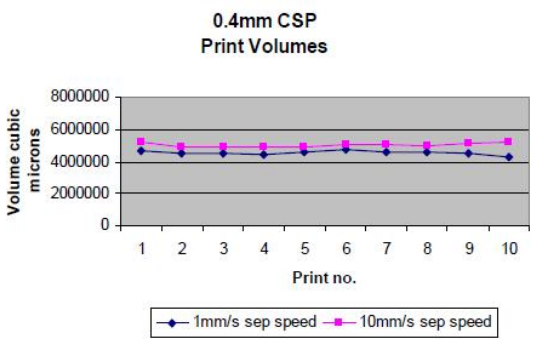
Printing: Volume Consistency

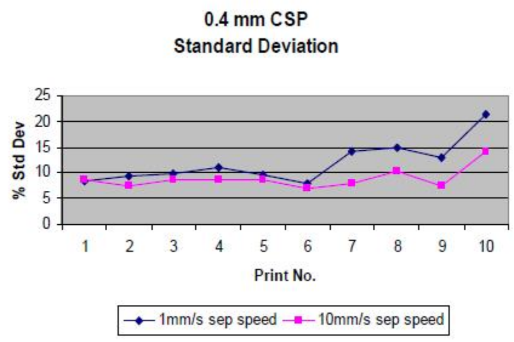
Printer	DEK Infinity, 50mm/s, 6Kg pressure, 250mm/60° metal squeegee
Stencil	Laser cut, stainless steel, 100µm (approx. 0.004”) thickness
Boards	Bare copper, no resist
Deposits Examined	0.4mm CSP, 245µm radius round aperture; 0.5mm CSP, square apertures, 270µm x 270µm square aperture; 0.4mm QFP, 220µm x 830µm rectangular apertures
Inspection	Cyberoptics SE300

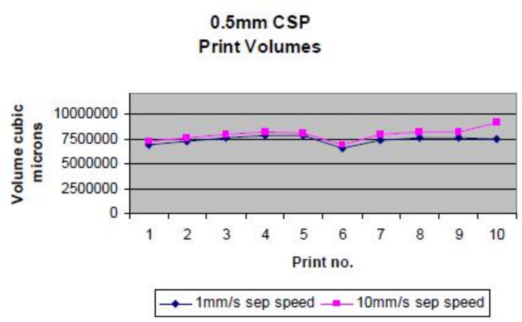


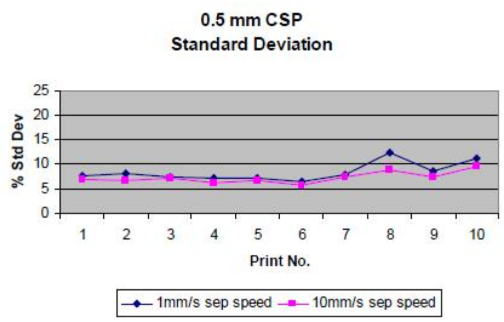
Operating Parameters

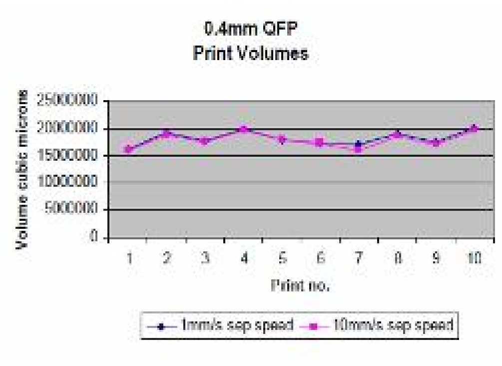
Printing: Volume Consistency

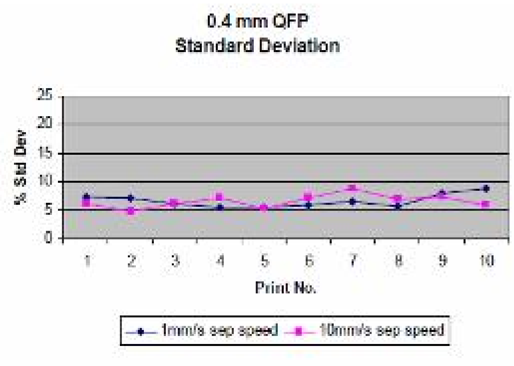










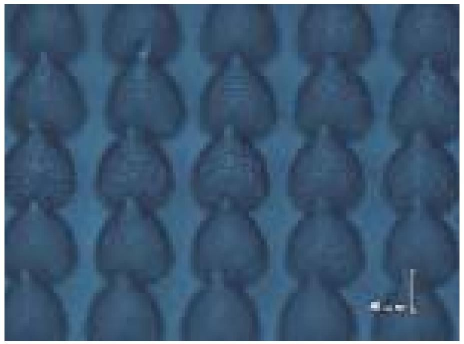


Operating Parameters

Dispensing: Equipment Parameters

Dispenser	Asymtek D555 Platform
Needle guage	EFD Smooth tapered tip 5118TT-B, 18guage (0.033"/0.84mm internal diameter)
Fluid pressure	0.1MPa (14.5psi)
Dwell Time	0.06s
Retract Distance	5.0mm
Retract Speed	25mm/s
Retract Acceleration	7620mm/s^2

0.6s dispense time
2.0mm pitch



0.75s dispense time
2.0mm pitch

Operating Parameters

Reflow: Process Window

- **Innolot LF318 solder paste was subjected to testing in Henkel laboratories to establish the reflow process window, using the following equipment**

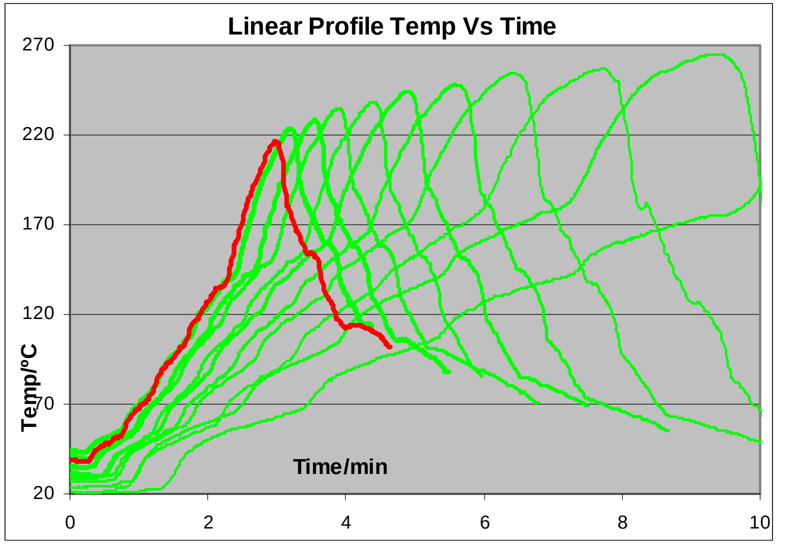
Printer	DEK260, 75mm/s (approx. 2”/s), 8kg pressure (approx. 17.5lbs)
Stencil	Laser cut, stainless steel, 125mm (approx. 0.005”) thickness
Boards	Bare copper, no resist
Reflow Oven	Seho FDS6440
Deposits Examined	0.64mm (approx. 0.025”) QFP100 (0.38mm (approx 0.015”) pads), 0.4mm (approx. 0.016”) TQFP100 (0.25mm (approx. 0.010”) pads), 0.3mm (approx. 0.012”) TQFP (0.2mm (approx. 0.008”) pads) and BGA225 (1.27mm (approx. 0.050”) pitch)
Inspection	Stereomicroscope (x10-x30)

- **Boards were printed and reflowed at varying times to peak process temperatures, from 2 to 12minutes**
- **Both linear and soak-type reflow profiles were used**
- **Reflow quality was assessed according to the appearance of the solder fillet and post-reflow residue, paying close attention to coalescence during reflow, solder surface appearance, solder balling, residue surface quality and colour**

Operating Parameters

Reflow: Process Window

- **Linear Reflow Profile**
- **Changes to the reflow profile were achieved by adjusting belt speed, to minimise the complexity of the test matrix zone temperature settings remained unchanged**



- **Acceptable reflow conditions**

  T>217°C: 11.5 – 171s

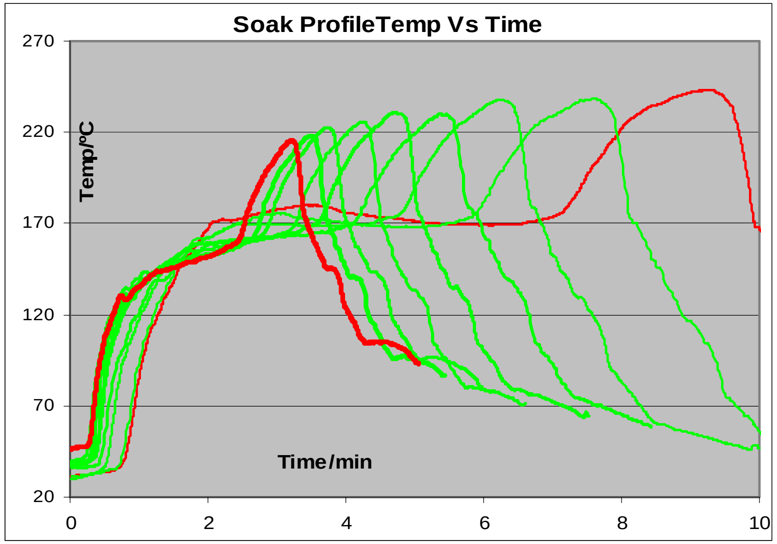
  Peak Temperature: 223 - 266°C

This data is provided to give an indication of the operating process window of the solder paste, optimisation of the assembly process should still be performed for each individual application

Operating Parameters

Reflow: Process Window

- **Soak Reflow Profile**
- **Changes to the reflow profile were achieved by adjusting belt speed, to minimise the complexity of the test matrix zone temperature settings remained unchanged**



- **Acceptable reflow conditions**

  T>217°C: 11.5 – 119s

  Peak Temperature: 223 - 247°C

  This data is provided to give an indication of the operating process window of the solder paste, optimisation of the assembly process should still be performed for each individual application

Operating Parameters

Reflow: Wetting (Oxidised Copper)

- Wetting behaviour of LF318 according to J-STD-005
- This test is carried out to determine the ability of a solder paste to wet an oxidised copper surface and to qualitatively examine the amount of solder spatter of the paste during reflow
- This test compares the performance of the material as printed and after 4hours storage under ambient conditions (25°C/50%RH)

- Initial (as printed)

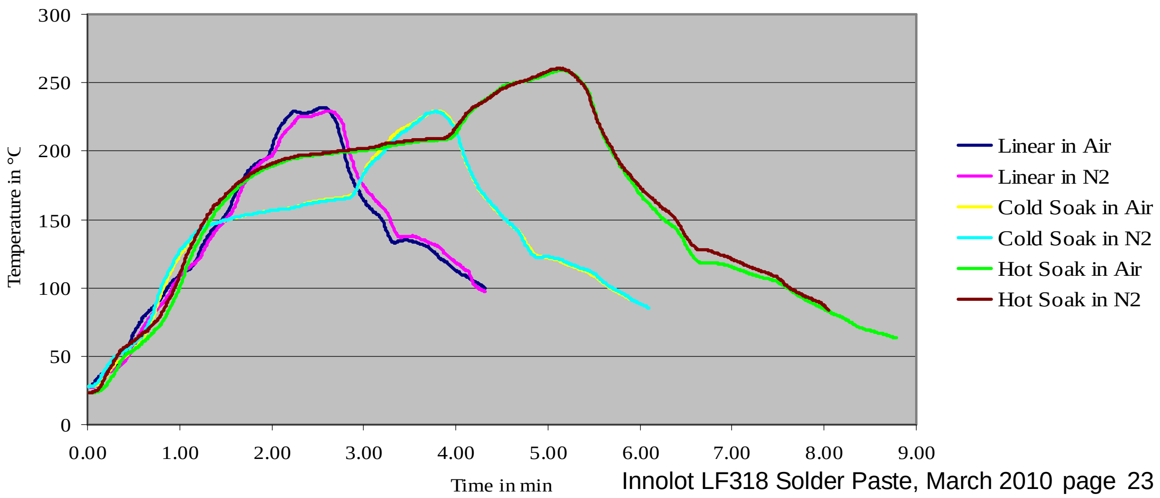
After 4hours storage (25°C/50%RH)

Reflow: Voiding

- **Innolot LF318 solder paste was subjected to testing in Henkel laboratories to establish the level of voids present, benchmarking was performed against standard SAC alloy**

Printer	MPM Accela, 50mm/s, 7.5kg pressure
Stencil	Laser cut, stainless steel, 125µm (approx. 0.005") thickness
Boards	OSP, Immersion Sn, NiAu
Reflow Oven	Seho FDS6440
Deposits Examined	BGA256 (with and without component)
Inspection	X-Tec Revolution

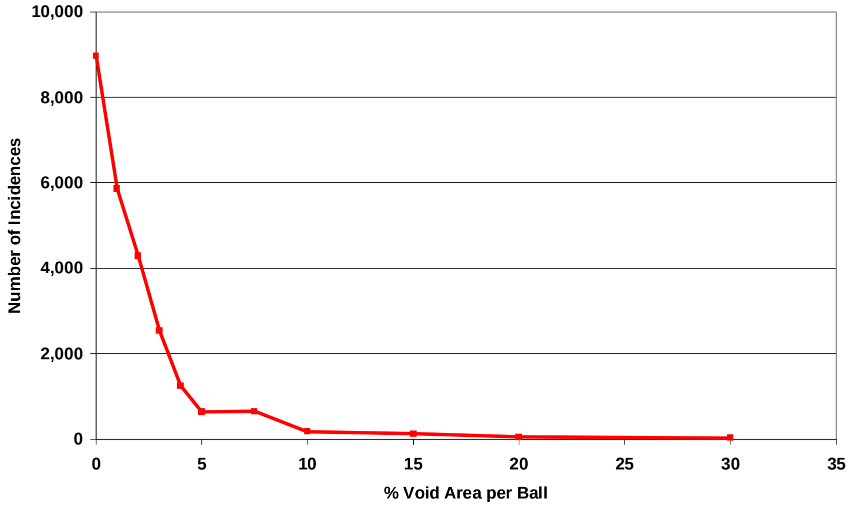
- **Profiles used**

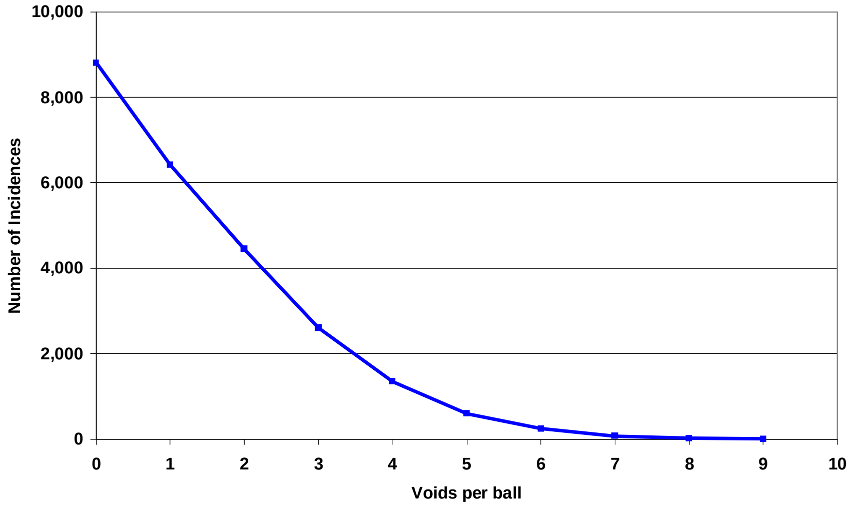


Operating Parameters

Reflow: Voiding

- **Voiding summary (consolidated for all test conditions)**

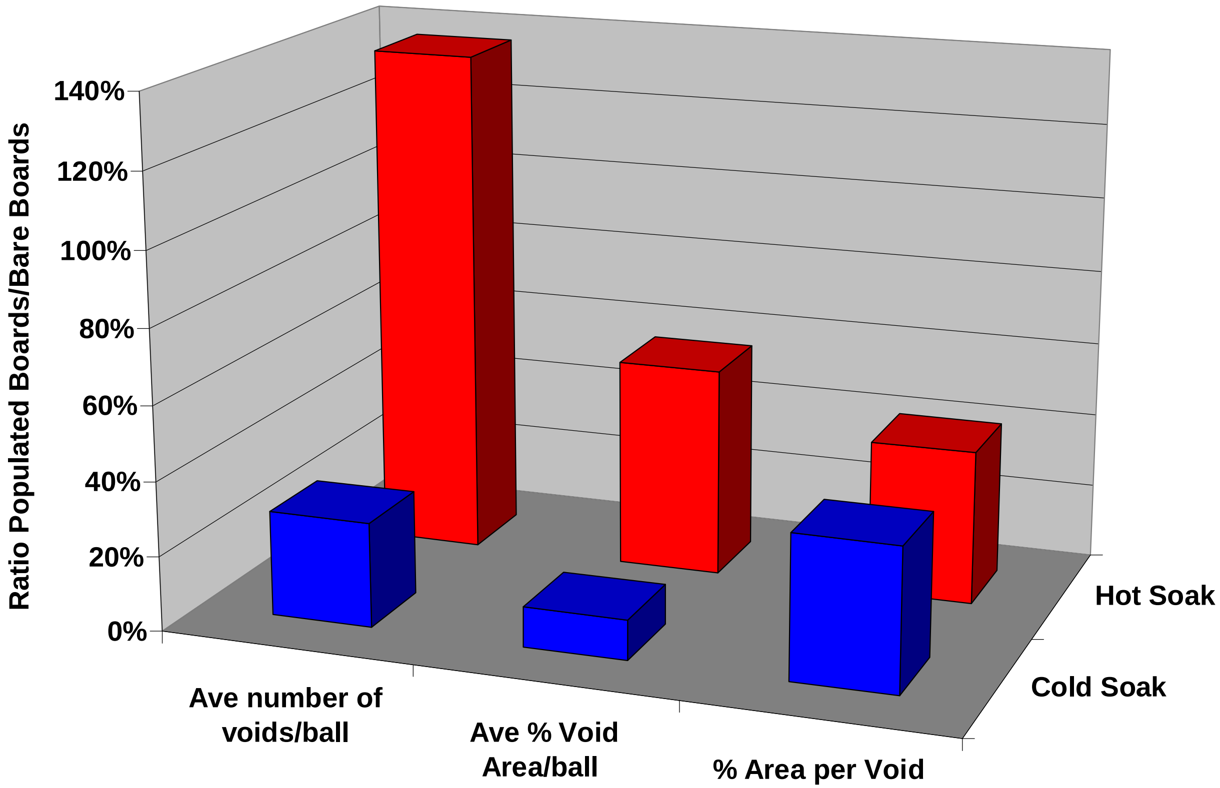




Operating Parameters

Reflow: Voiding

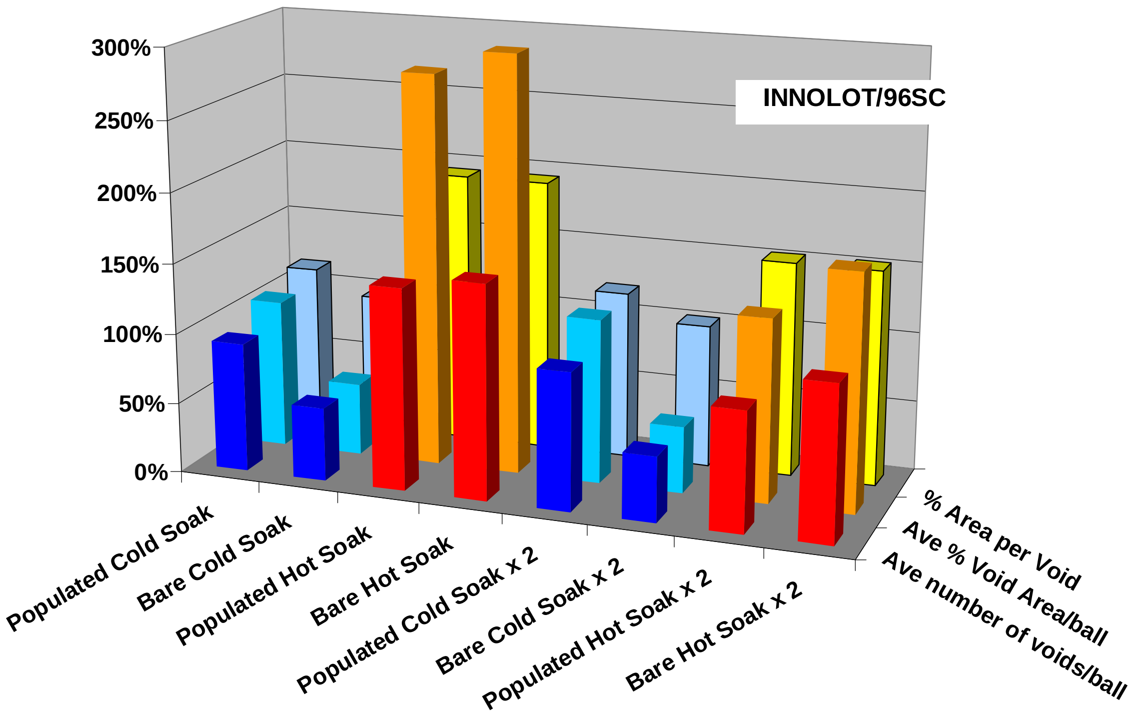
- Comparison of unpopulated vs. populated BGA pads (unpopulated boards act as reference at 100%)



Operating Parameters

Reflow: Voiding

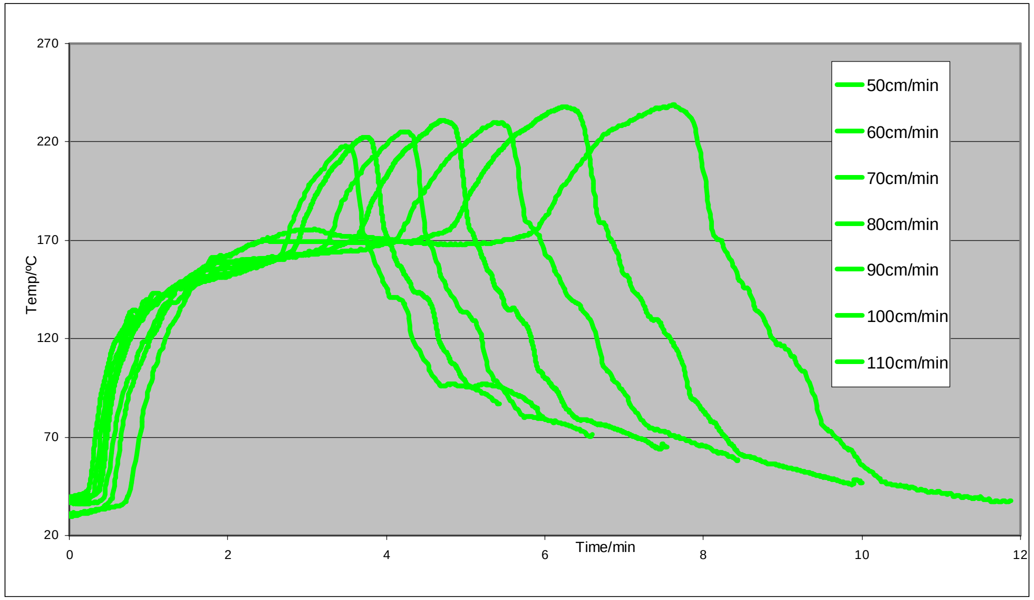
- Overall voiding summary vs. SAC alloy (SAC alloy data acts as a reference at 100%)



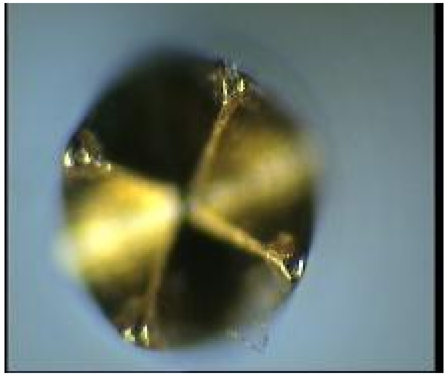
Operating Parameters

Pin Testing

- Pin Testing in Air
- Profile adjusted by changing belt speed
- Pin test done on copper laminate; electrical continuity during testing monitored using an electric counter
- Test done using 4-pin crown point probe (Croda PA4QPS-040)
- 840 test points per PCB



BELT SPEED cm/ min	BOARD NUMBER	% contacts using 4 point plain crown probe on 840 pads	RESULT
50	1	100	PASS
60	2	100	PASS
70	3	100	PASS
80	4	100	PASS
90	5	100	PASS
100	6	100	PASS
110	7	100	PASS



Test Data

J-STD-004 Reliability test results

- J-STD-004: copper mirror
- IPC-TM-650 2.3.32
- Flux induced corrosion
- No breakthrough of copper: flux classification ‘L’

- J-STD-004: halide test
- IPC-TM-650 2.3.33
- Silver chromate paper method
- No discolouration of silver chromate paper: flux activity classification ‘0’

- J-STD-004: fluoride test
- IPC-TM-650 2.3.35.1
- No change in colour from purple to yellow confirms absence of fluorides
- Flux activity classification ‘0’

Test Data

J-STD-004 Reliability test results

- J-STD-004: chlorides and bromides
- IPC-TM-650 2.3.35
- Measurement of chloride and bromide concentrations
- Content measured at <0.005%

- J-STD-004: Halide content by ion chromatography
- IPC-TM-650 2.3.28.1
- Chloride equivalent calculated at 0.013%

- J-STD-004: flux solids
- IPC-TM-650 2.3.34
- Flux solids (non-volatile content) determination
- Solids content measured at 69%

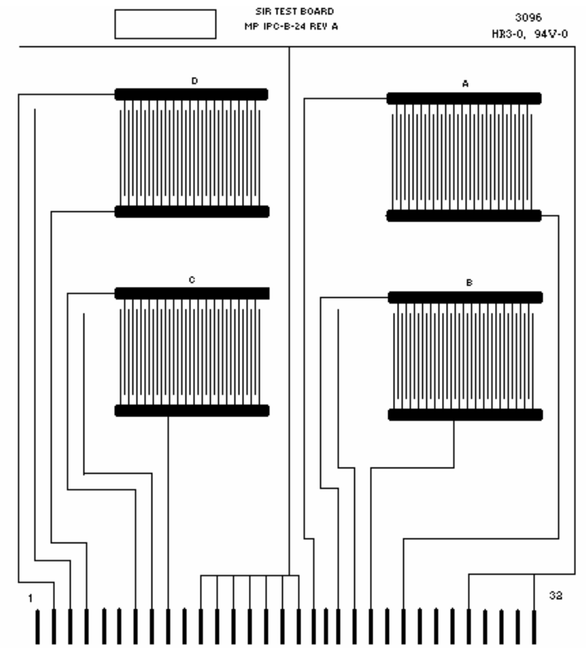
- J-STD-004: flux corrosion
- IPC-TM-650 2.6.15
- No evidence of corrosion: flux classification ‘L’
- Test performed in duplicate: 240hours (10days) humid storage at 40°C/93%RH

Test Data

J-STD-004 Reliability Test Results

- **J-STD-004: Surface Insulation Resistance**
- **IPC-TM-650 2.6.3.3**
- **Passmark: 1 x $10^8\Omega$**

	24hours at 85°C/85%RH, 50V bias	96hours at 85°C/85%RH, 50V bias	168hours at 85°C/85%RH, 50V bias
Control (Ω)	5.89 x 10^9	3.60 x 10^9	2.85 x 10^9
LF318 (Ω)	3.13 x 10^9	1.03 x 10^9	1.06 x 10^9
Passmark (Ω)	1.00 x 10^8	1.00 x 10^8	1.00 x 10^8



Test Data

J-STD-004 Reliability Test Results

- **JIS-Z-3284: Surface Insulation Resistance**
- **Passmark: 1 x $10^8\Omega$**

	Initial at 25°C/50%RH, no bias	24hours at 85°C/85%RH, 50V bias	96hours at 85°C/85%RH, 50V bias	168hours at 85°C/85%RH, 50V bias
Control (Ω)	8.94×10^{11}	1.51×10^{9}	1.26×10^{9}	1.27×10^{9}
LF318 (Ω)	7.44×10^{11}	1.73×10^{9}	1.75×10^{9}	1.96×10^{9}
Passmark (Ω)	1.00×10^{8}	1.00×10^{8}	1.00×10^{8}	1.00×10^{8}

- **JIS-Z-3284: Electromigration**
- **No dendritic growth observed**

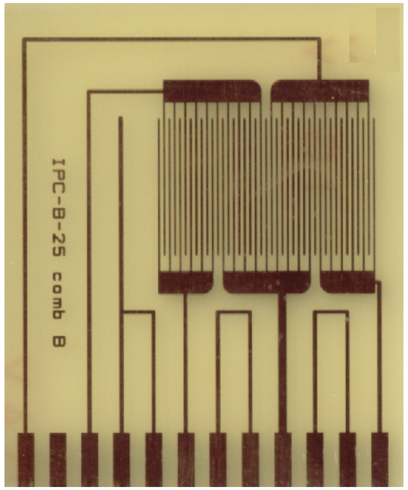
Test Data

GR-78-CORE Reliability Test Results

- **GR-78-CORE: Surface Insulation Resistance**
- **Passmark: 1 x $10^{10}\Omega$**

	24hours at 35°C/85%RH, 50V bias	96hours at 35°C/85%RH, 50V bias
Control (Ω)	1.80 x 10^{11}	1.47 x 10^{11}
LF318 (Ω)	1.49 x 10^{11}	1.84 x 10^{11}
Passmark (Ω)	1.00 x 10^{10}	1.00 x 10^{10}

- **IPC-B-25 test pattern (0.0125” spacing)**



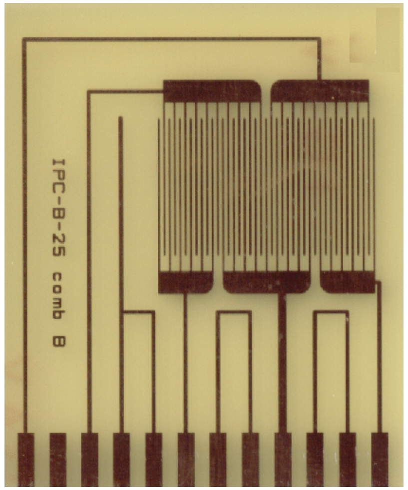
Test Data

GR-78-CORE Reliability Test Results

- **GR-78-CORE: Electromigration**
- **Passmark: Degradation in insulation resistance by no more than 1decade, no evidence of dendritic growth**

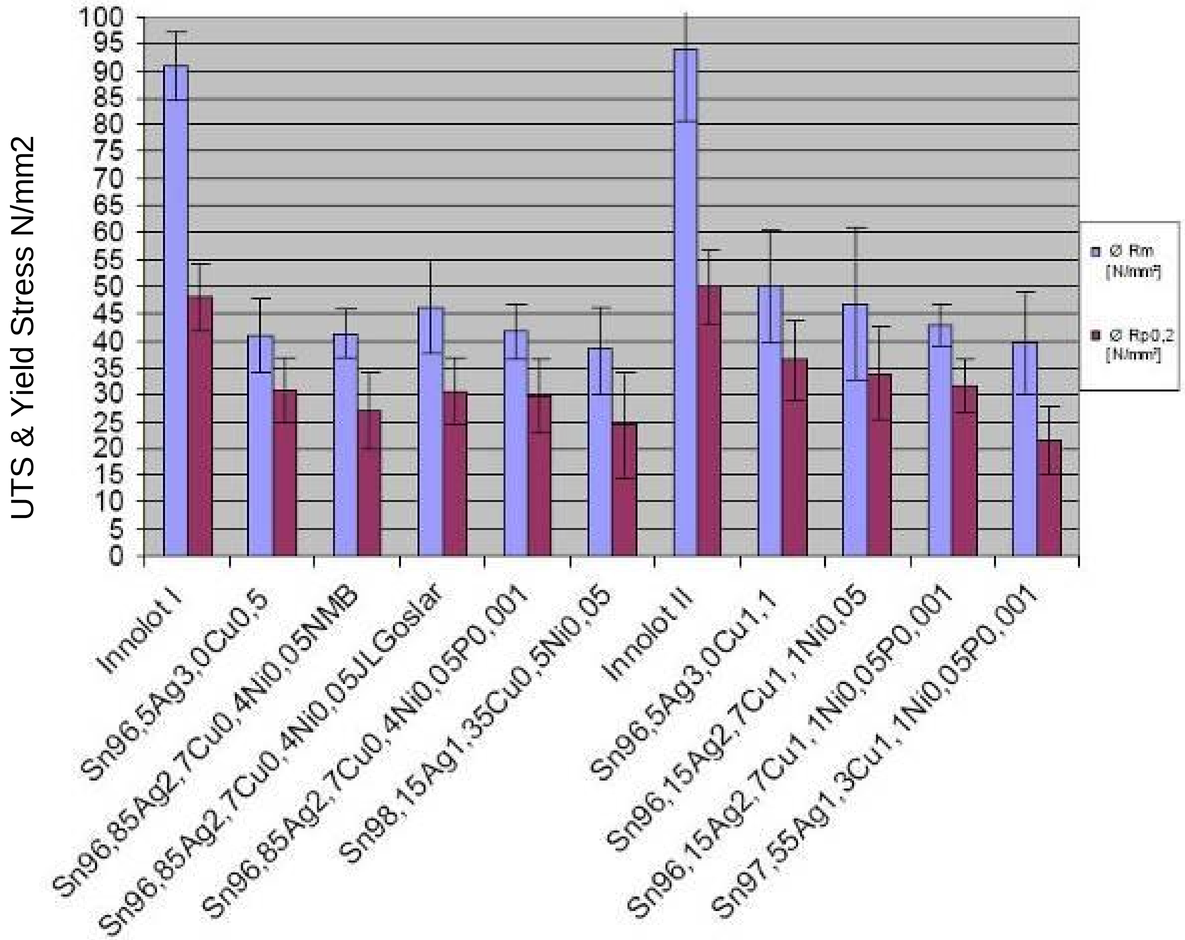
	96hours at 65°C/85%RH, 10V bias	500hours at 65°C/85%RH, 10V bias
Control (Ω)	2.59×10^{10}	5.24×10^{10}
LF318 (Ω)	3.73×10^{10}	3.47×10^{10}
Passmark (Ω)	-	-

- **IPC-B-25 test pattern (0.0125" spacing)**



Test Data

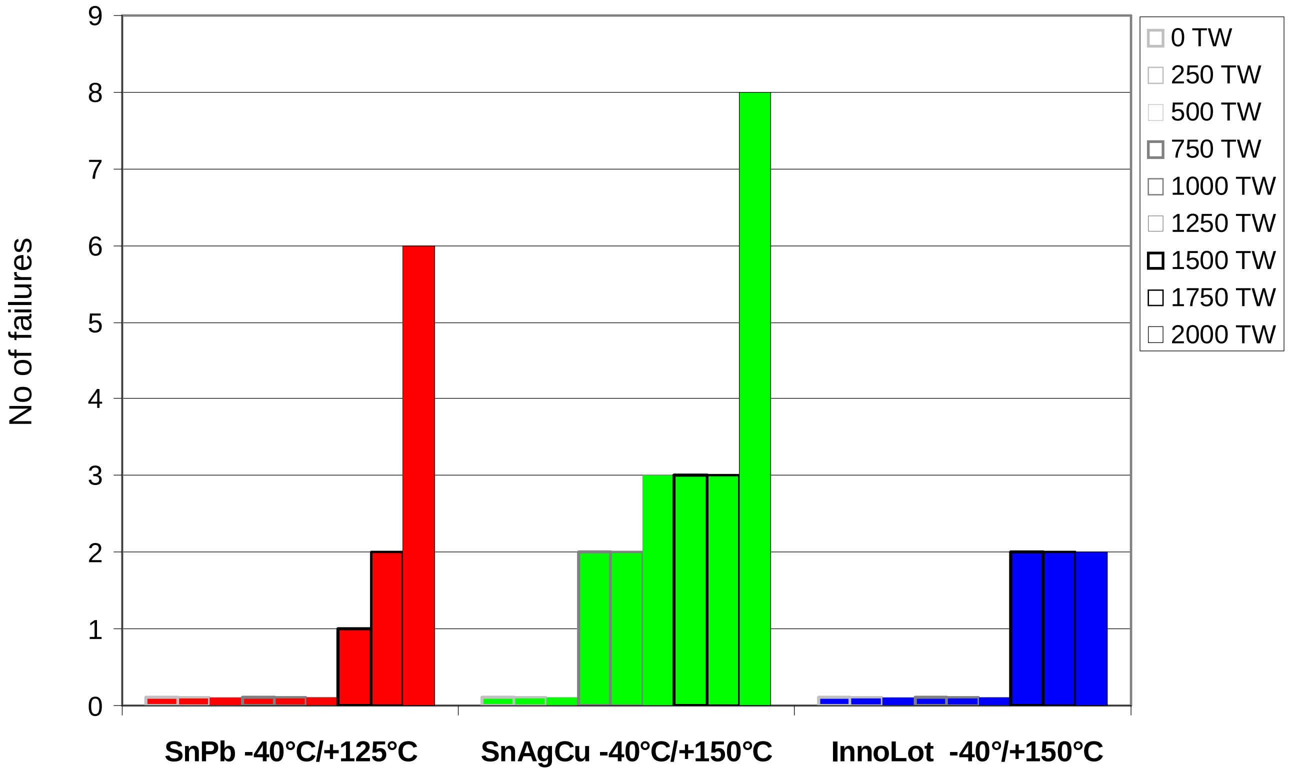
Innolot Reliability: Tensile Strength



UTS & Yield Stress for Solders at Room Temperature

Test Data

Innolot Reliability: Thermal Cycle

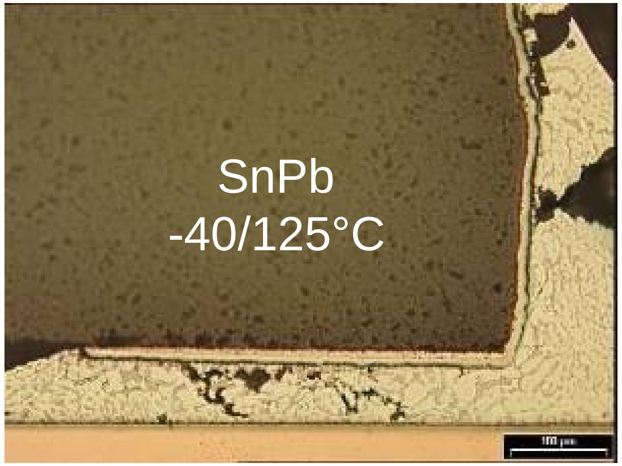


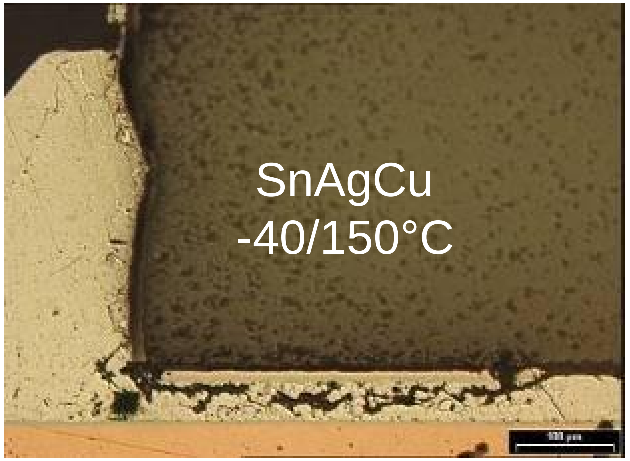
40 Chip-components from CR0402 - CR2512 per Board, no failures on TO263, QFP and SO16

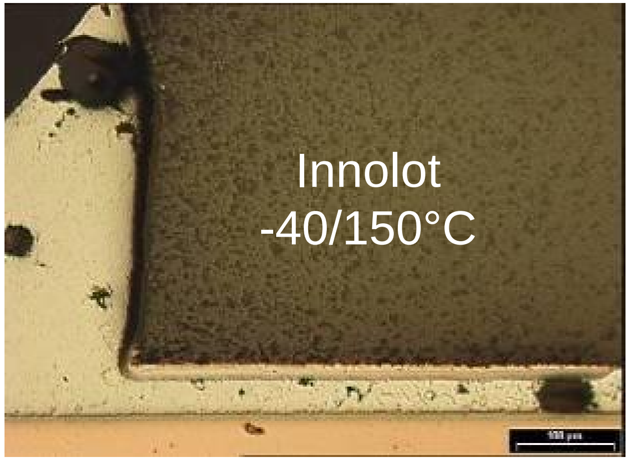
Each bar on the graph represents 250 thermal cycles

Test Data

Innolot Reliability: Thermal Cycle



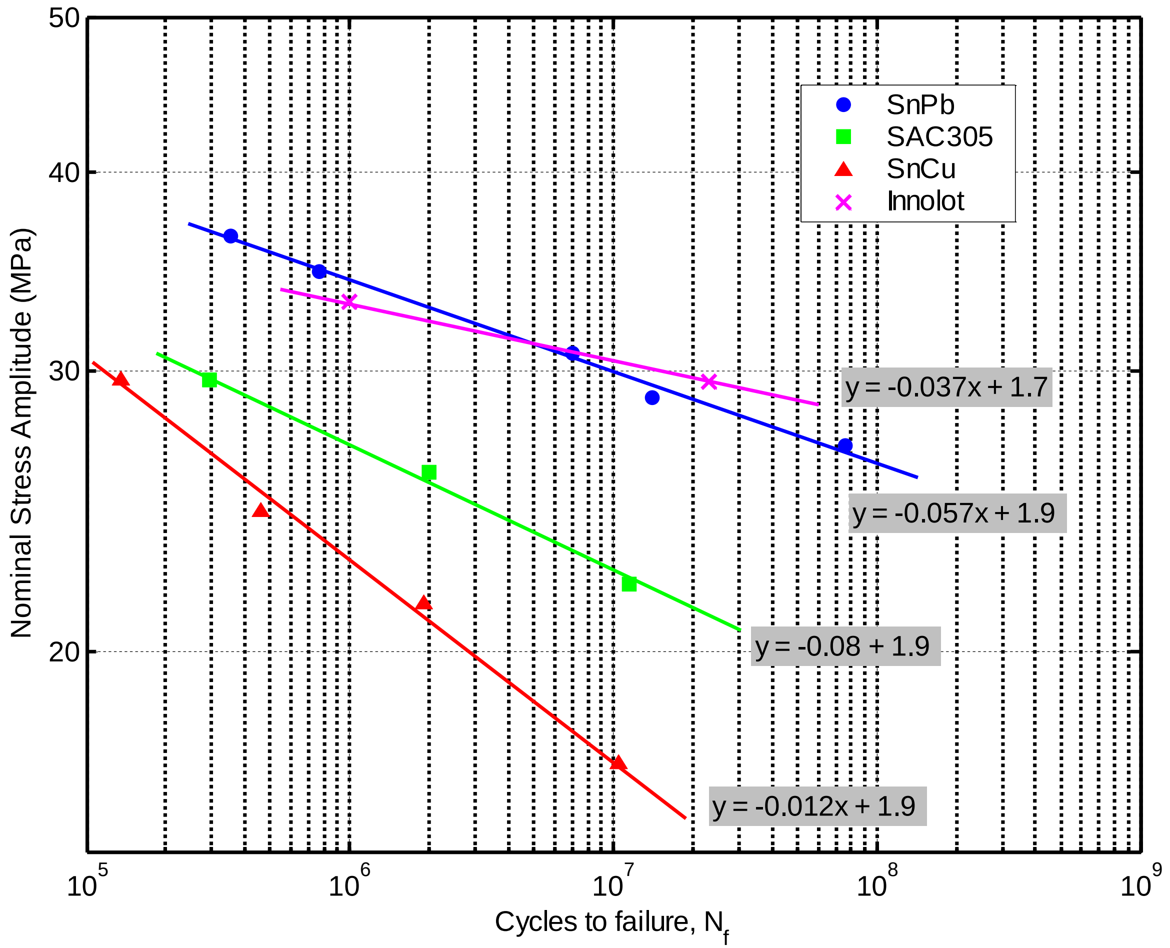




Alloy structure after 1000cycles

Test Data

Innolot Reliability: Vibration

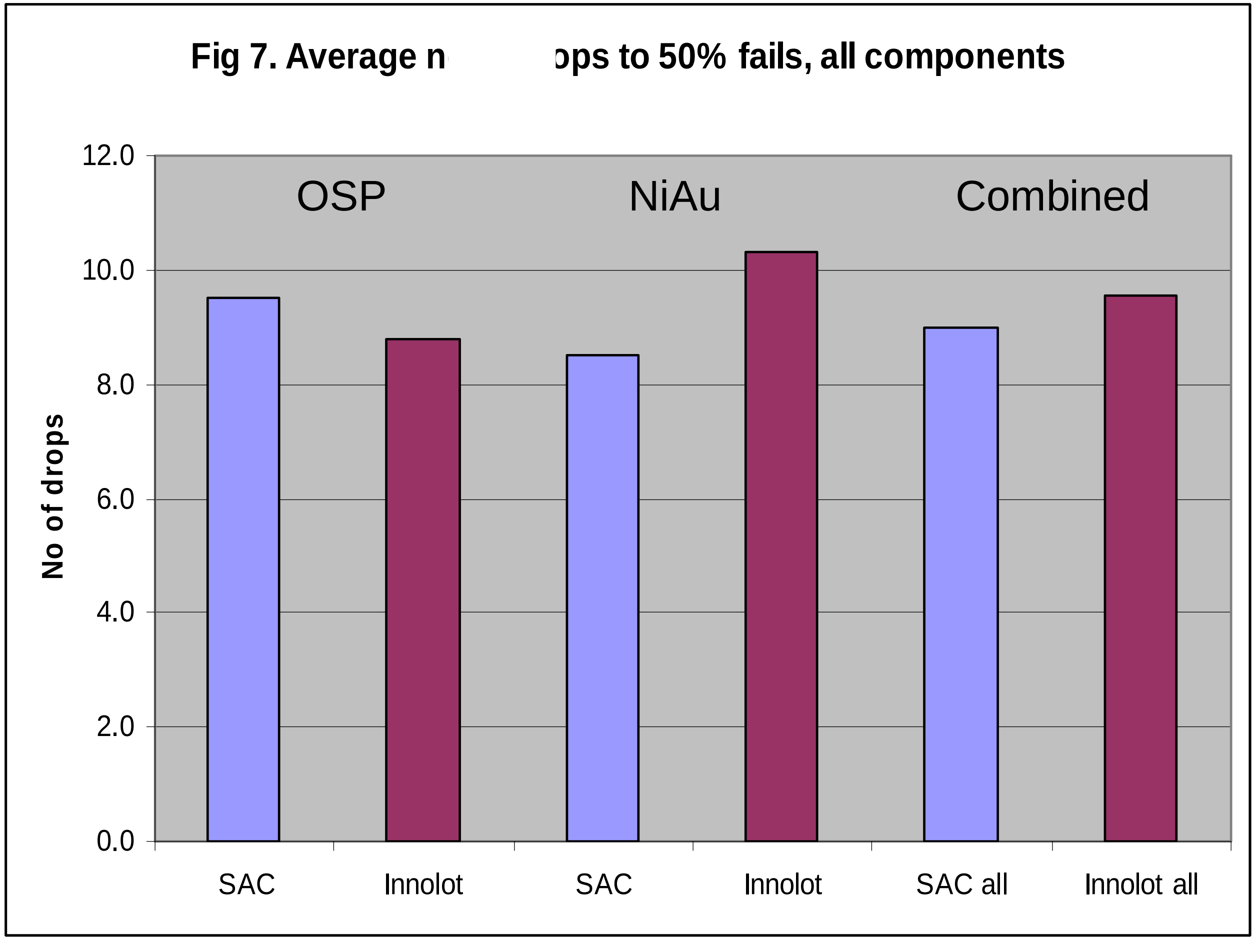


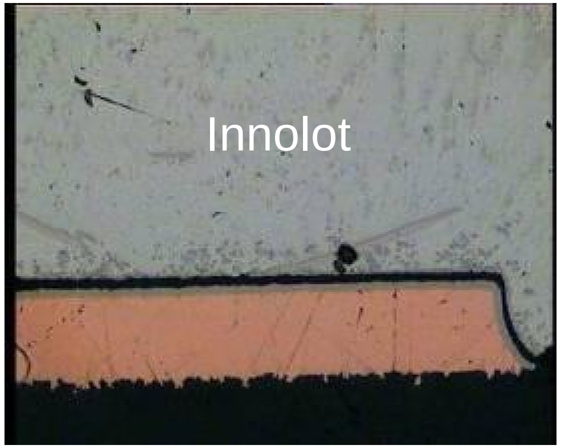
Innolot performs similarly to SnPb

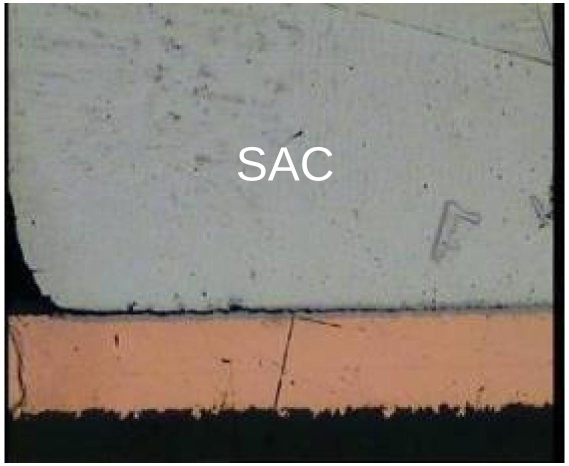
Clearly outperforms SAC305 & SnCu (Sn100C)

Test Data

Innolot Reliability: Drp Testing







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