JCAA/JGPP Lead-Free Solder Testing for High Performance Applications: Data Utilization & NASA Phase II Programs

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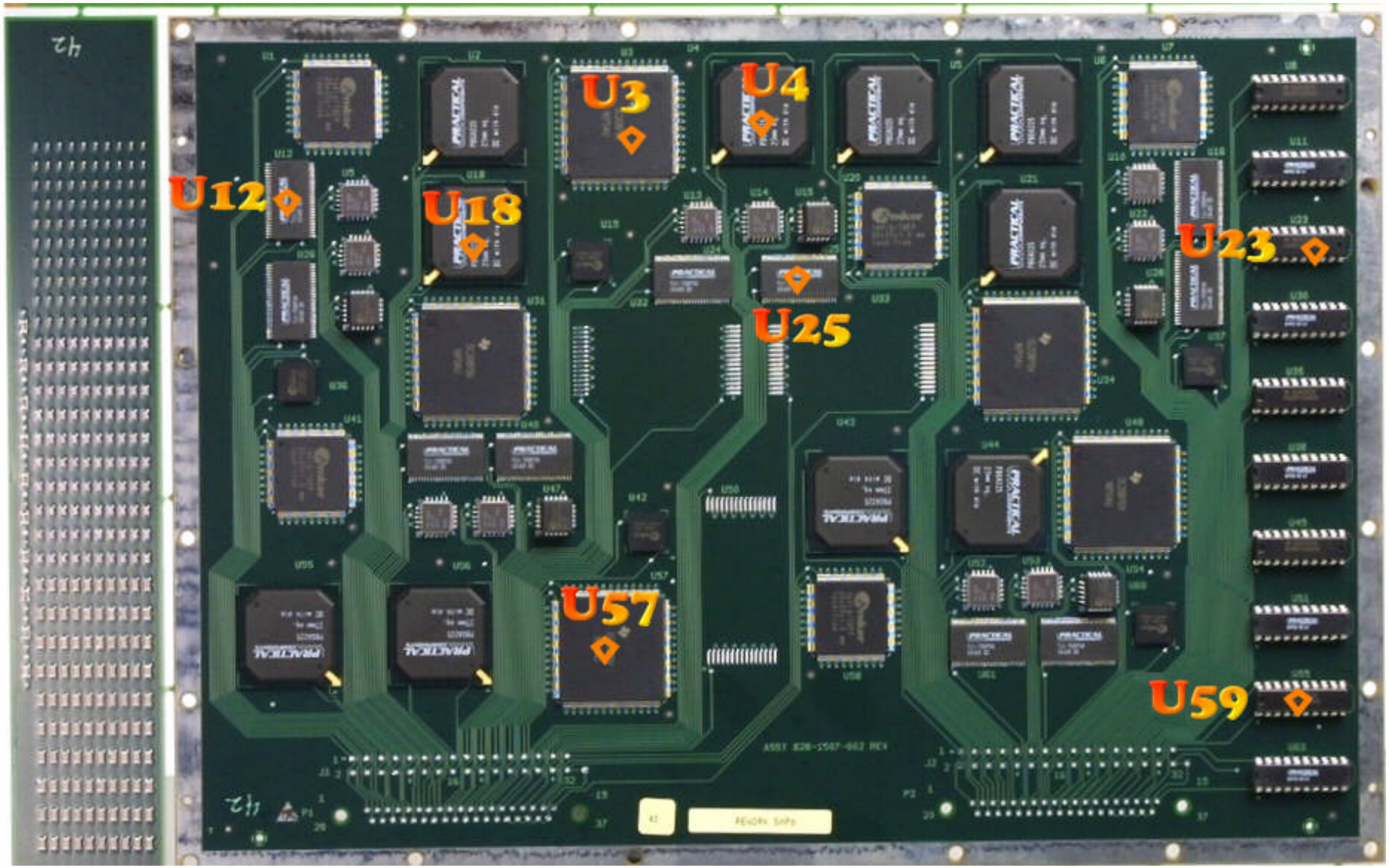
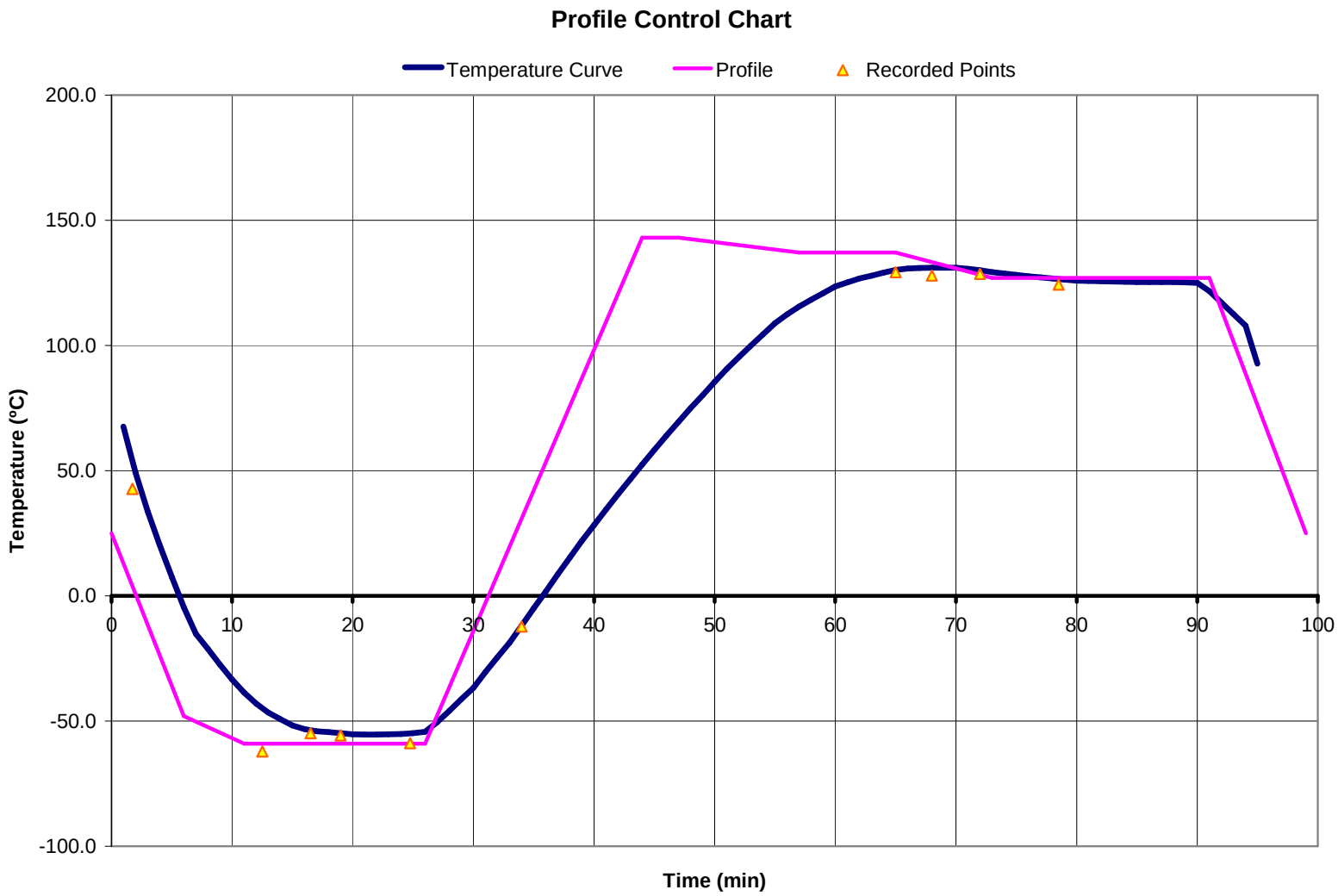
Outline:

- JCAA/JGPP Brief Project Background
- JCAA/JGPP Thermal Testing Information
- NASA Phase II Efforts
- JCAA/JGPP Links & NASA Phase II POC

JCAA/JPGG Phase I Test Vehicle



Thermal Cycle Profile for the -55ºC to +125ºC Conditioning



JCAA/JGPP Phase I Thermal Cycle Results:

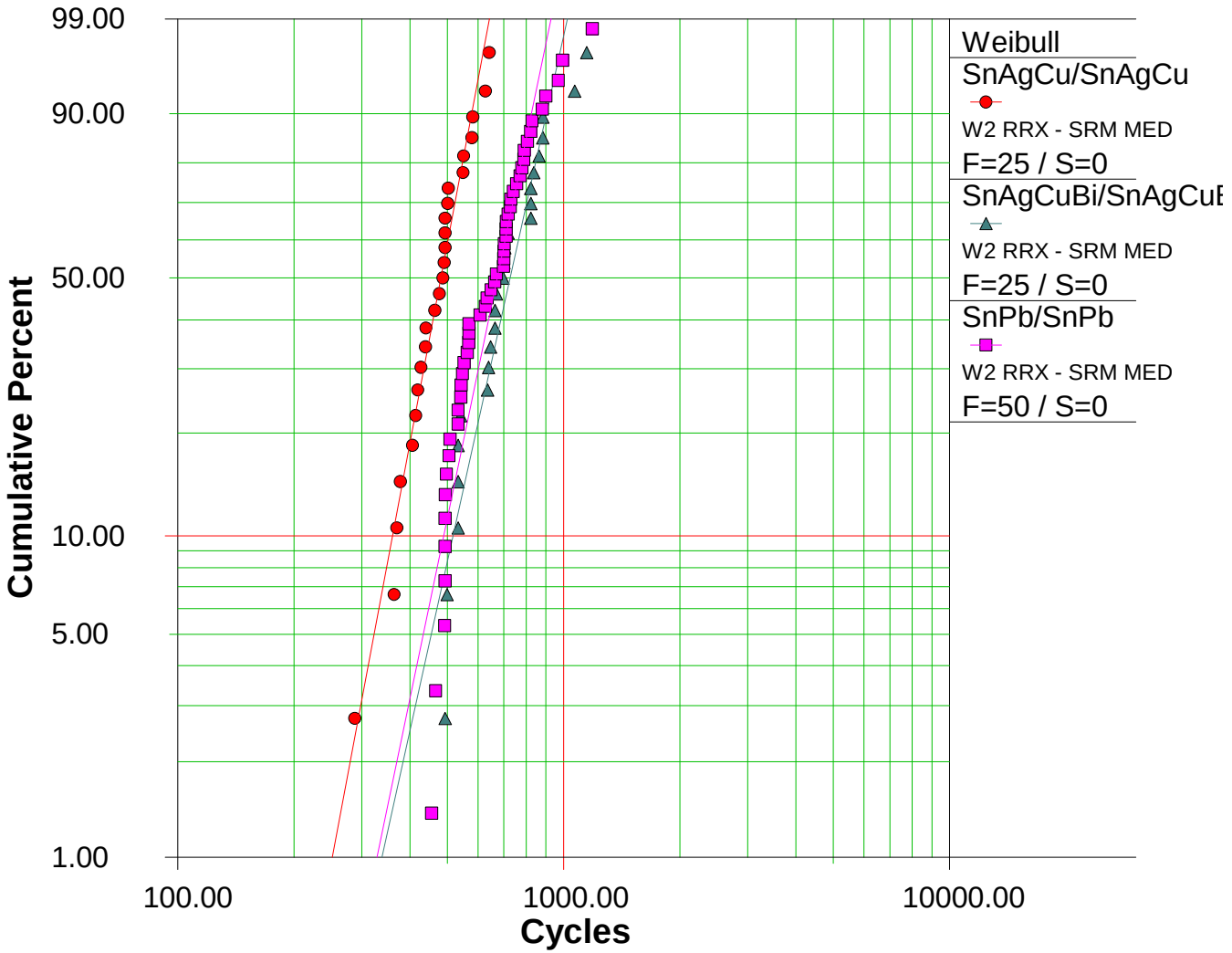
JCAA/JGPP Phase I Thermal Cycle Results:

- **4743 Total Thermal Cycles Completed**
  - **12 months of Testing !!!**

Component Type	Total Failures	Total Population	Percent Failured
BGA 225	257	300	85.7
CLCC 20	300	300	100
PDIP 20	24	300	8
PLCC 20	8	150	5.3
TQFP 144	136	150	90.7
TQFP 208	110	150	73.3
TSOP 50	296	300	98.7

Thermal Cycle Results:

CLCC-20 test results - Manufactured test vehicles (170ºC Tg)

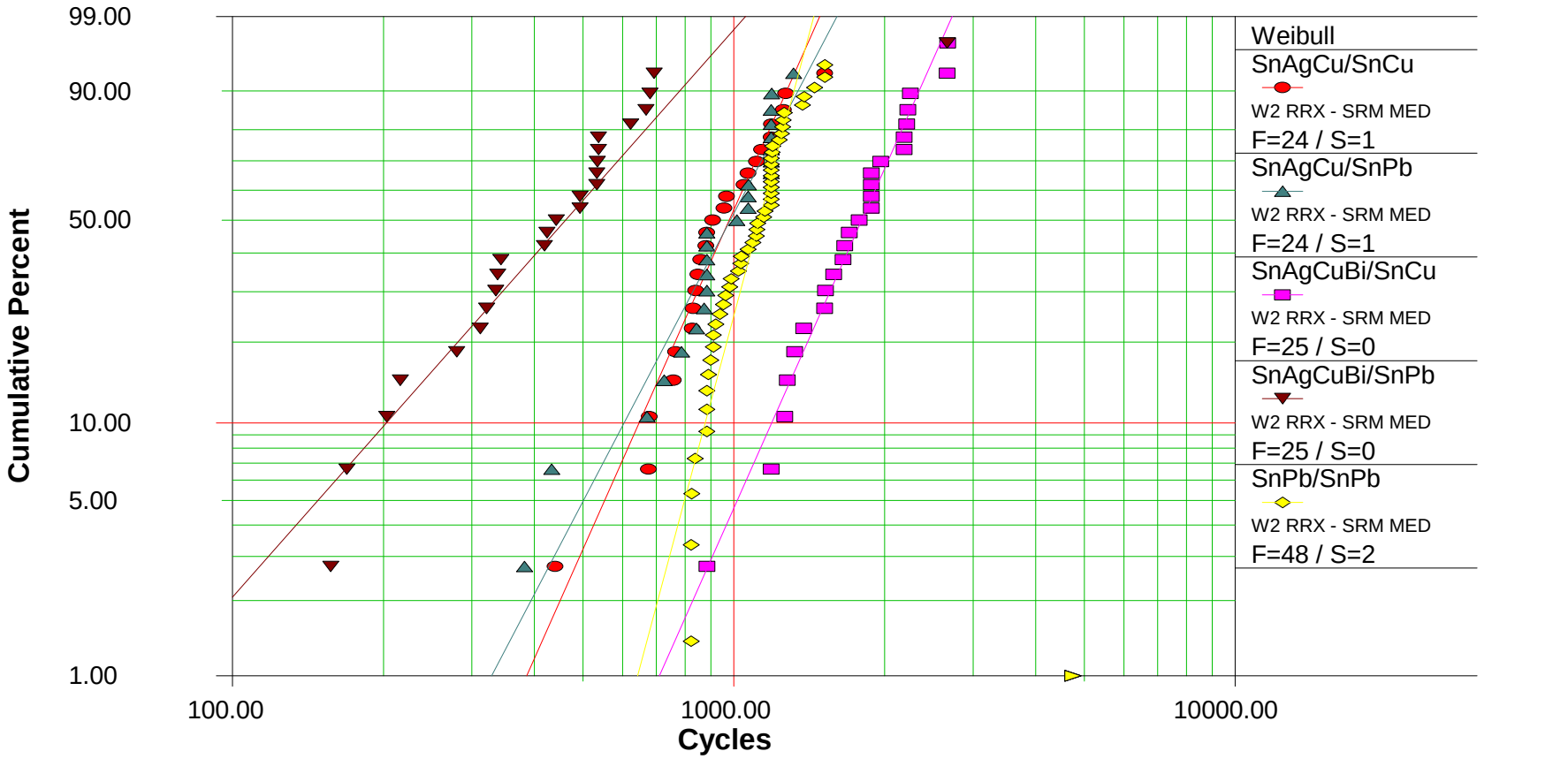


β1=6.5409, η1=508.6653, ρ=0.9864
β2=5.5317, η2=776.3182, ρ=0.9453
β3=5.9047, η3=716.4935, ρ=0.9326

Key: Solder Alloy/Component Finish

Thermal Cycle Results:

TSOP-50 test results - Manufactured test vehicles (170ºC Tg)

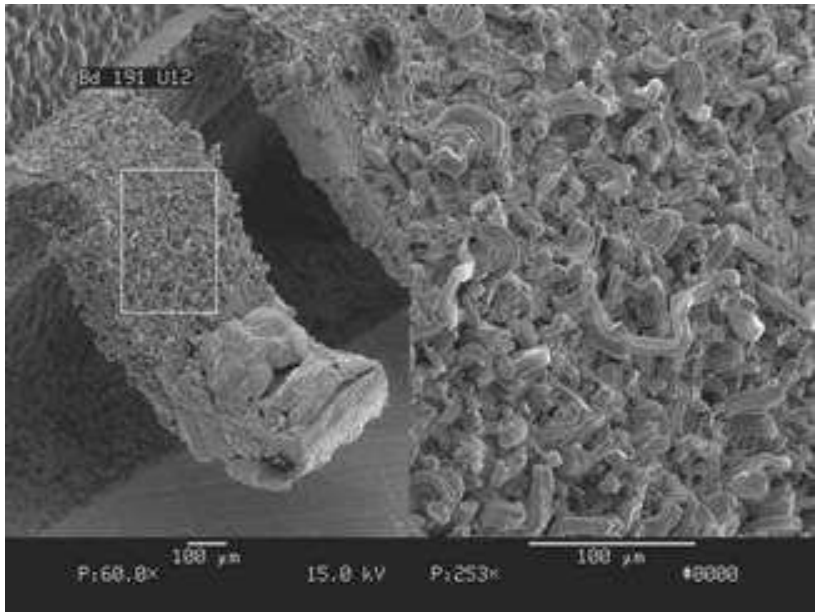


β1=4.5501, η1=1061.7576, ρ=0.9732
β2=3.8599, η2=1082.2162, ρ=0.9642
β3=4.5553, η3=1950.6106, ρ=0.9890
β4=2.2892, η4=542.1344, ρ=0.9096
β5=7.5694, η5=1179.9001, ρ=0.9443

Key: Solder Alloy/Component Finish

Failure Analysis Results: Components/Finishes:

Component Type	Component Finish
CLCC -20	SnPb
	SnAgCu
	SnAgCuBi
PLCC-20	Sn
TSOP-50	SnPb
	SnCu
TQFP-144	Sn
TQFP-208	NiPdAu
BGA-225	SnPb
	SnAgCu
DIP-20	Sn
	NiPdAu
0402 Capacitor	Sn
0805 Capacitor	Sn
1206 Capacitor	Sn
1206 Resistor	Sn



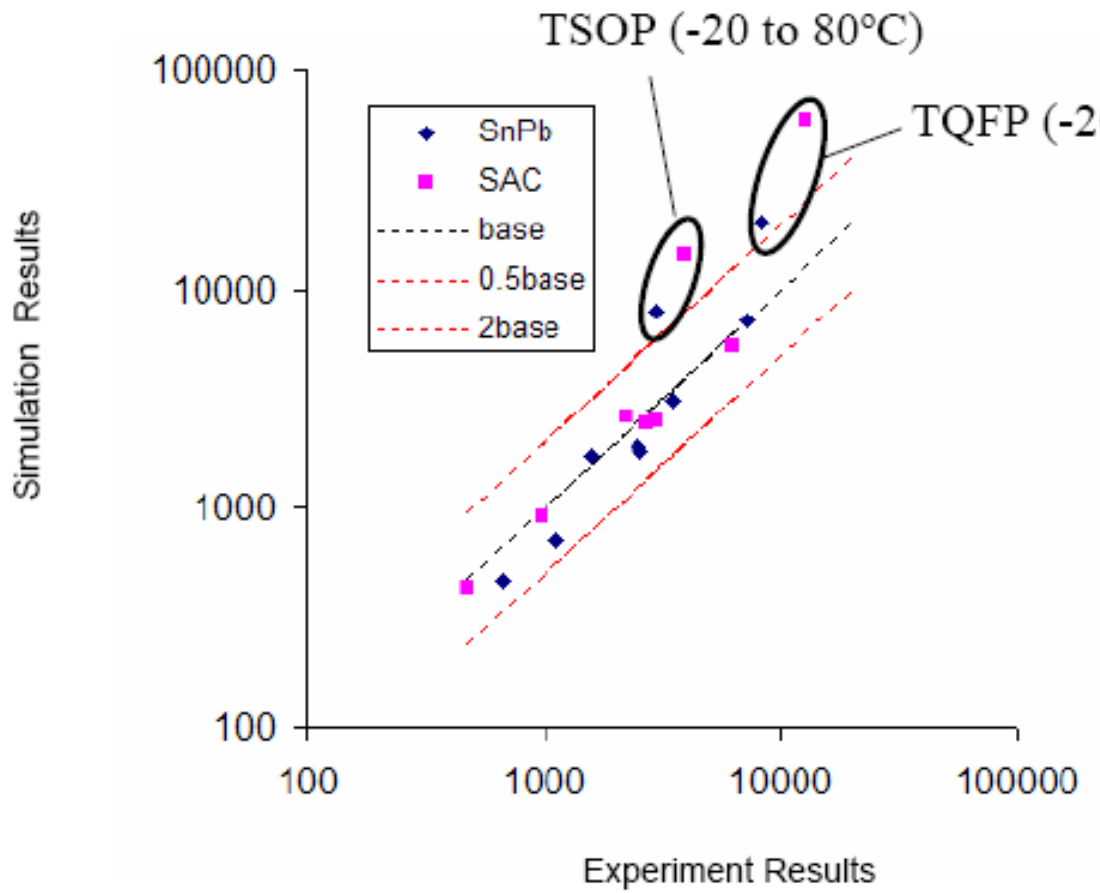
Joint Test Report (JTR): Example of Data Coverage

Relative Solder Performance -20 to +80°C Thermal Cycle "Manufactured" Test Vehicles				
Component	**Solder/Finish**	**1st Failure**	**N10**	**N63**
CLCC-20	SnPb/SnPb	0	0	0
	SAC/SAC	+	++	++
	SACB/SACB	++	++	++
	SAC/SnPb	0	-	0
	SACB/SnPb	+	+	+
TSOP-50	SnPb/SnPb	0	0	0
	SAC/SnCu	+	++	++
	SACB/SnCu	0	+	++
	SAC/SnPb	+	+	+
	SACB/SnPb	--	--	--

0 = Same as Control (5% or less difference)

CALCE Modeling Results of JGPP Data:

Comparison of Simulation Results



Parts include (BGA, CLCC, TSOP, TQFP). Current model over estimates life of leaded parts. This result is likely due to the square of ΔT in estimating the strain range for leaded parts.

CALCE Modeling Results of JGPP Data:

Table 1. $N_{50\,\%}$ between reported and simulated values for various packages

			Data from [11, 12]				
	Solder Material	Package type	$N_{63.2\,\%}$ (cycles)	β	$N_{50\,\%}$ (cycles)	$N_{50\,\%}$ (simulated)	Difference (%)
TC 1	SnPb	CLCC20	709	5.7	664	473	- 28.8
		PBGA225	2671	6.2	2516	1907	- 24.2
		TQFP144	2672	7.4	2542	1834	- 27.8
		PQFP208	3798	4.6	3506	3118	- 11.1
		TSOP50	1180	7.6	1124	708	- 37.0
	SAC	CLCC20	508	6.54	480	435	- 9.4
		PBGA225	3447	2.65	3002	2528	-15.8
		TQFP144	3550	1.44	2754	2418	-12.2
		PQFP208	8121	1.52	6381	5476	-14.2
		TSOP50	1060	4.55	978	919	- 6.0
		CLCC20	1671	8.5	1600	1731	8.2

NASA Lead-Free Solder Testing: Phase II

Goals:

1) Generate reliability data for circuit cards manufactured and reworked with SnPb and lead-free solders and subjected to rigorous environmental exposure conditions.

2) Provide baseline data for aerospace and defense (high-performance) applications.

Key Question Being Addressed:

To what extent does Rework procedures, including SnPb and lead-free mixed solder joints, affect solder joint reliability of high-performance electronics, using SnPb as a baseline?

NASA Lead-Free Solder Testing: Phase II

SnPb Manufactured		Lead-Free Manufactured	
Surface Finish	**Solder Alloy**	**Surface Finish**	**Solder Alloy**
Immersion Ag	**Reflow = SnPb Wave = SnPb**	**Immersion Ag**	**Reflow = SAC305 Wave = Sn100C**
Reflow Profile: Preheat = ~ 120 seconds @140 183°C Peak temperature = 225°C Time above reflow = 60-90 sec Ramp Rate = 2-3 °C/sec	**Wave Profile: Solder Pot Temperature = 250°C Preheat Board T = 101°C Peak Temperature = 144°C Speed: 110 cm/min**	**Reflow Profile: Preheat = 60-120 seconds @150-190°C Peak temperature target = 243°C Reflow:~20 seconds above 230°C ~30-90 seconds above 220°C**	**Wave Profile: Solder Pot Temperature = 265°C Preheat Board T = 134°C Peak Temperature = 157°C Speed: 90 cm/min**

Table 2 Rework Test Vehicles

SnPb Rework		Lead-Free Rework	
Surface Finish	**Solder Alloy**	**Surface Finish**	**Solder Alloy**
Immersion Ag ENIG	**Reflow = SnPb Wave = SnPb**	**Immersion Ag**	**Reflow = SAC305 Wave = Sn100C**
Reflow Profile: Preheat = ~ 120 seconds @140-183°C Peak temperature = 225°C Time above reflow = 60-90 sec Ramp Rate = 2-3 °C/sec	**Wave Profile: Solder Pot Temperature = 250°C Preheat Board T = 101°C Peak Temperature = 144°C Speed: 110 cm/min**	**Reflow Profile: Preheat = ~ 120 seconds @140-183°C Peak temperature = 225°C Time above reflow = 60-90 sec Ramp Rate = 2-3 °C/sec**	**Wave Profile: Solder Pot Temperature = 265°C Preheat Board T = 134°C Peak Temperature = 157°C Speed: 90 cm/min**

Additional JCAA/JG-PP Results:

- **JCAA/JGPP Consortia Joint Test Report (JTP) Contains Final Report and Data**

- **Weblink: http://acqp2.nasa.gov/LFS.htm**

•NASA Phase II POC
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Questions?

This is categorized as an issue!