"Solder Fatigue in Tin-Lead and Silver-Tin-Copper (ROHs) solders"

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Please come see us at our booth.

www.thermalanalysissystems.com

Background for Today's Topic

- **RoHs – how does it affect the solderability of parts**
- **Who is using what solders and why?**
- **What is solder fatigue and why is it important?**
- **What kind of thermal extremes affect the analysis?**
- **Why do parts fail?**
- **We do all this electrical testing – why isn't it working?**
- **How does this save money?**
- **What does this mean for the circuit board?**

I have the answers and reasons to all the above concerns and questions.

RoHS – Restriction of Hazardous Substances

What is RoHS and why is it important.

The "Restriction of Hazardous Substances Directive," most commonly referred to as RoHS

- **proposed in 2003 by the European Union to control six hazardous materials from reaching landfills.**
- **July 2006 - RoHS enactment in the United States and Canada.**
- **The RoHS goal is to prevent - lead (Pb), mercury (Hg), cadmium (Cd), hexavalent chromium (Cr6+), polybrominated biphenyls (PBB) and polybrominated diphenyl ether (PBDE).**

RoHS – Effect on Electronics

What does RoHS mean for Electronics.

It changes the materials used in circuit board production and assembly.

1. **Tin solders reduce reliability due PCB pad cratering, trace fractures, inner plane separation, and poorly formed solder joints.**
2. **Using 100% tin - tin whisker issues.**
3. **Raises the process temperatures by more than 20°C**

What can we do about it? Chose your solder and materials correctly for your product.

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Solder Choices?

- **New Solder choices are available.**
- **The melting temperatures are 30 C or more higher than previous tin-lead solders (183 C).**
- **Board materials may need to be changed for less CTE (Coefficient of thermal expansion).**

Choose your new solder wisely – there will be wetting differences, solder joint fragility, and higher temperatures.

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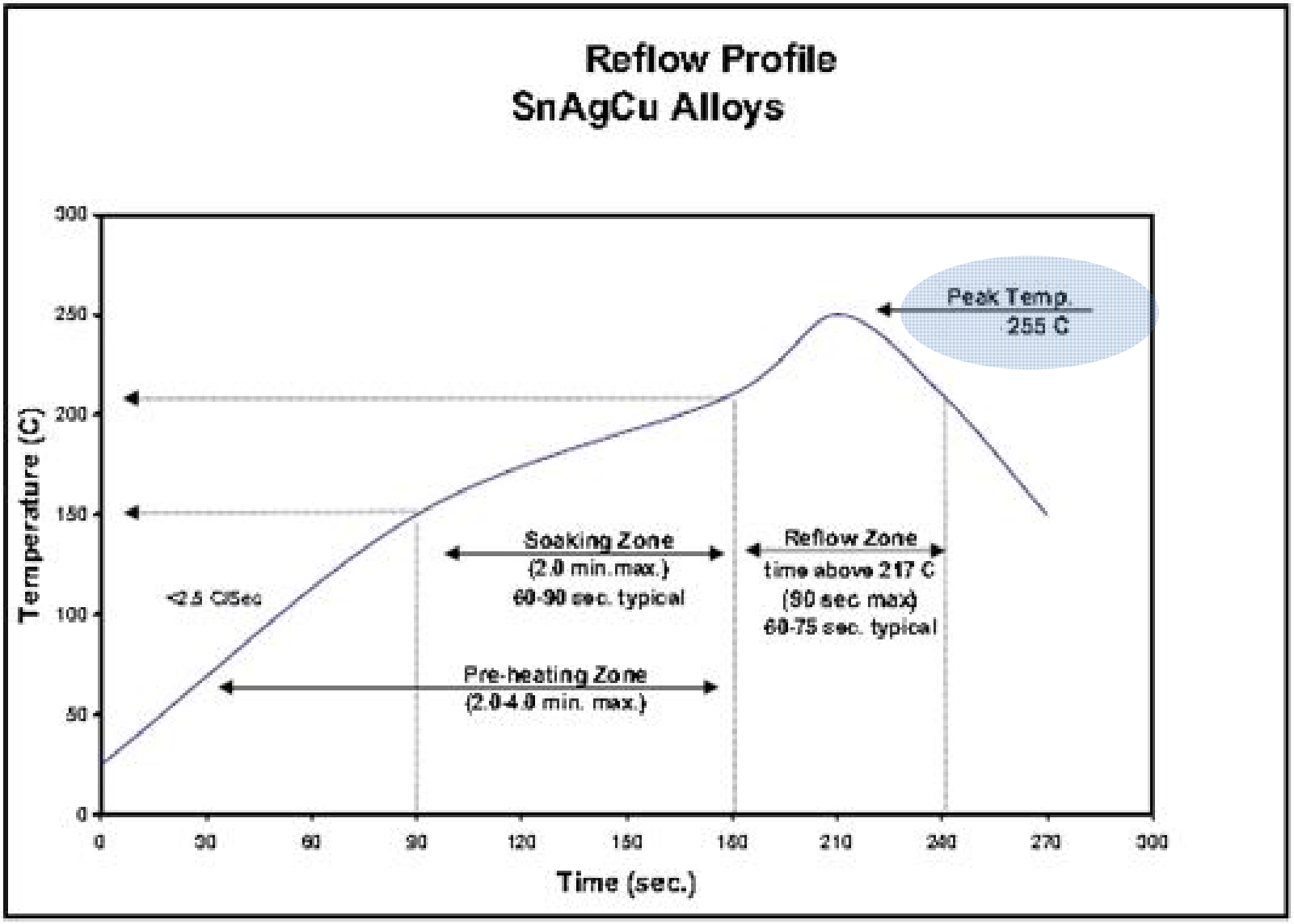

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Solder Fatigue

- **Solder fatigue is a creep phenomenon.**

- **Caused by:**
  - **large temperature excursions,**
  - **small temperature deltas,**
  - **power cycling and**
  - **low power standby modes.**

So how do we analyze these?

Analyzing Fatigue

For solder fatigue caused by drastic temperature changes:

- **matching thermal coefficients assures meeting military specifications.**
- **But - it can cause non-representative material concerns.**

For industries where power cycles and/or smaller temperature variations

- **damage is due to cyclic warpage or increased cyclic strains on the solder joints.**
- **These deformations and strains are in-plane shear strains,**

This can be calculated analytically or experimentally reproduced. If not done correctly, the "effective strain" will be underestimated by 25%.

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Thermal Testing

Standard thermal cycling is an unsuitable test for assessing power cycle damage to a design.

Why?

- **Normally test cycling is based on a temperature delta and the differences in the coefficient of thermal expansion.**
- **In this case, it is very small so the calculation and testing would indicate a small damage total.**

So what do we do?

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Power Cycle Testing

- **The thermal cycling to experimentally produces these stresses must include longer durations to allow the stress relaxation to occur.**
- **Additionally localized temperature deltas should be simulated to add the damage that starts in the microcosm and moves into the system.**

Advanced Planning and Testing can make this work.

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Different Solders

Other differences:

- **due to the material composition differences in the ROHs silver-tin-lead solders.**
- **It is generally accepted that high Ag SAC alloys (SAC305/405) have good thermal fatigue resistance and actually perform better than the popular SnPb solders.**
- **The presence of Ag results in Ag3Sn precipitates which causes increased hardness and strength.**
- **But silver solders have poor high-strain rate response. So failures occur in shock due to this ductility difference.**

Watch out for strength and ductility differences!

Fatigue Calculations

- Max damage
- Avg damage
- Shock damage
- Mech. stress damage

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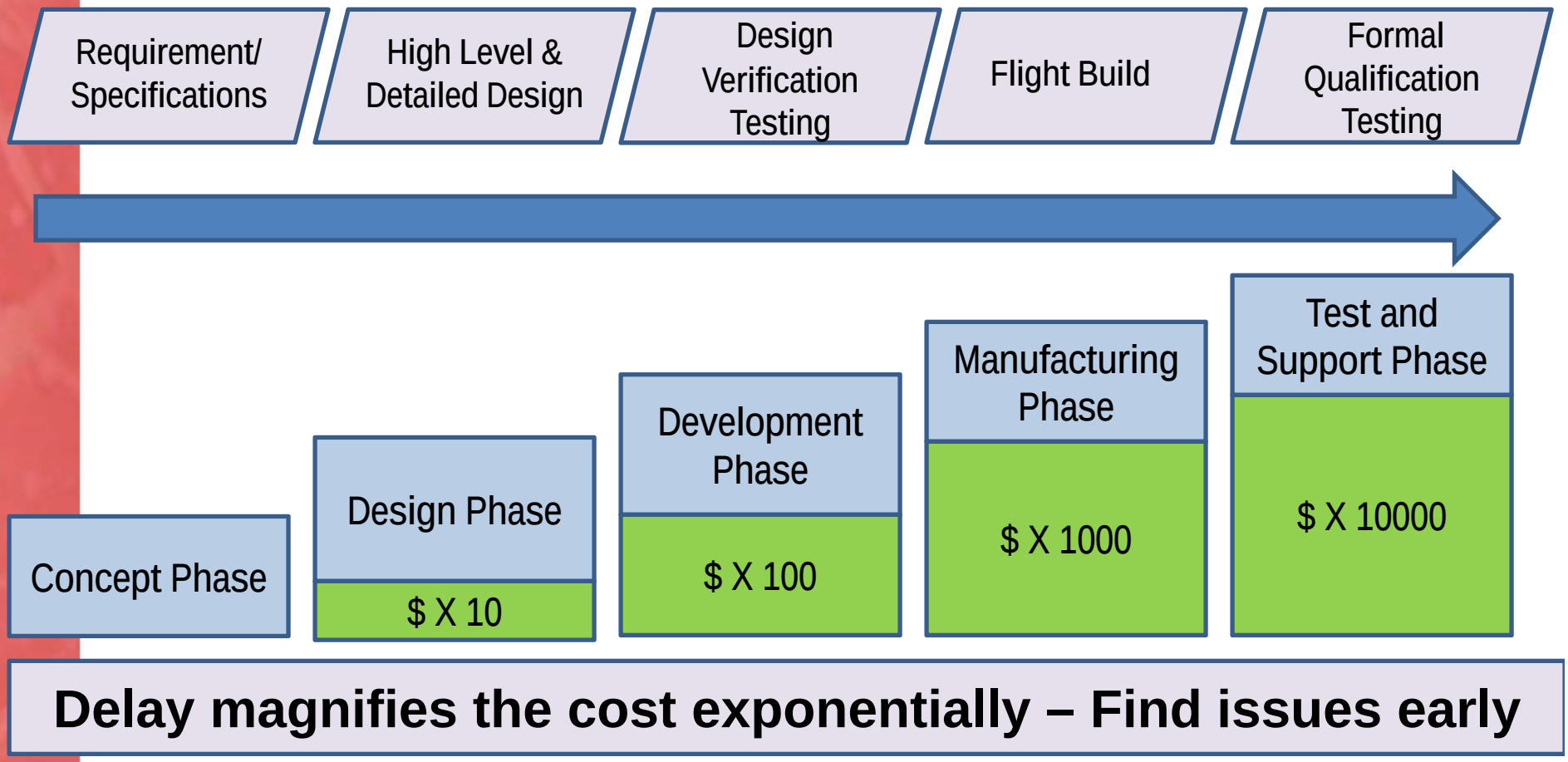
= Total Damage

	MEAN FATIGUE LIFE CYCLE		
	Average Life	Maximum Life	Total Life
Cycle 1	13,712,128	37,487,281	51,199,410
Cycle 2	5,500,135	14,298,465	19,798,600
Cycle 3	4,752,578	12,255,587	17,008,165

Time	Cycle 1	Cycle 2	Cycle 3
5 years	0.001074	0.000001	0.000001
10 years	0.002148	0.000002	0.000001
life cum	0.002152		

Use multiple cycles to make the separate cases for average and maximum thermal conditions.

Find Issues
Earlier Rather Than Later



Delay magnifies the cost exponentially – Find issues early

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Summary

- As a designer or analyses – keep an open mind for new ideas, but don't just accept that newer is better.
- Keep the end goal in mind – maintain or improve reliability while minimizing costs and schedules, volume and weight.
- RoHS regulations – watch out for 100% tin
- Solder choices – watch out for material incompatibilities
- Increased temperature – plan for the extra heat
- Test new design thoroughly. New materials are new designs too.

Take-Away

The old saying is true – they are packaging 10 lbs. of electronics in a 5 lb. bag (and now it's hotter).

Thank You.

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