

Crimp Qualification Testing: Tin vs. Tin/Lead

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Introduction

The conversion to lead free products and processes is now imminent. Publication of the ELV directive and the RoHS directive ensures that lead use in electronics will rapidly decline over the next few years. This testing was performed to document the performance of tin electroplated coatings as a replacement for tin/lead platings in crimp interconnects.

Test Method

The testing follows SAE/USCAR-21, Performance Standard For Cable-To Terminal Electrical Crimps (issued May 2002). USCAR is the United States Council for Automotive Research. A consortium of representatives from Ford, General Motors and DaimlerChrysler to promote joint research in non-competitive areas that can strengthen the US automotive industry. (www.uscar.org).

Materials and Samples

Six representative crimp connector products were sampled in sizes ranging from 12 to 18 AWG. 10 crimps were made for each plating condition and crimp height. The crimp height was varied in three steps, using the minimum, maximum and nominal values. The samples were then exposed to environmental conditioning as per section 4.5.2.

1. Visual inspection per paragraph 4.2, and dry circuit resistance per paragraph 4.5.3.
2. Thermal Shock per paragraph 4.5.5, 72 Cycles, 30 ± 5 min. at +125° ± 3°C, 30 ± 5 min. at -40° ± 3°C
3. Dry circuit resistance per paragraph 4.5.3.
4. Temperature Humidity per paragraph 4.5.4, 4 Cycles :

16 hrs. ± 5 min. @ 95-98% R.H. @ +65° ± 3°C	}	Humidity not controlled
2 hrs ± 5 min. @ -40° ± 3°C		
2 hrs ± 5 min. @ +85° ± 3°C		
4 hrs ± 5 min. @ +23° ± 3°C		
5. Visual inspection per paragraph 4.2 and dry circuit resistance per paragraph 4.5.3

Table 1. Parts tested in this evaluation.

Part Number	Part Description	Base Metal
1326030-8	2.8mm Female	Cu-Ni-Si
638078-1	HDSF size 16 pin (2 sizes)	C26000, brass
1326029-8	2.8mm Male	C19700, iron-copper
638174-1	Category 1, Male	Phosphor bronze
770520-3	AMP Seal, Female	Cu-Ni-Si

Results

Part number	1326030-8
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Product Name	2.8mm Female					
Wire Size	12 AWG					
Requirement	Max $\Delta R < 0.33 \text{ m}\Omega$					
Crimp Height	0.067		0.069		0.071	
Plating	Sn-Pb	Lead Free	Sn-Pb	Lead Free	Sn-Pb	Lead Free
	0.10	0.01	0.00	0.01	0.02	0.06
	0.10	0.04	0.01	0.01	0.05	0.02
	0.00	0.01	0.12	0.00	0.12	0.02
	0.01	0.01	0.08	0.01	0.08	0.03
	0.04	0.00	0.05	0.09	0.06	0.05
	0.01	0.07	0.12	0.01	0.14	0.03
	0.05	0.02	0.02	0.01	0.09	0.01
	0.08	0.01	0.05	0.01	0.05	0.01
	0.05	0.01	0.03	0.02	0.09	0.05
	0.04	0.02	0.02	-0.01	0.10	0.08
Min	0.00	0.00	0.00	-0.01	0.02	0.01
Max	0.10	0.07	0.12	0.09	0.14	0.08
Std Dev	0.04	0.02	0.04	0.03	0.04	0.02
Average	0.05	0.02	0.05	0.02	0.08	0.04

Part number	638078-1					
Product Name	HDSF Size 16 pin					
Wire Size	14 AWG					
Requirement	Max $\Delta R < 0.33 \text{ m}\Omega$					
Crimp Height	0.062		0.064		0.066	
Plating	Sn-Pb	Lead Free	Sn-Pb	Lead Free	Sn-Pb	Lead Free
	0.03	0.01	0.00	0.04	0.01	-0.01
	0.01	-0.01	0.02	0.00	0.00	0.08
	0.01	0.05	0.01	0.04	0.00	0.01
	0.02	-0.01	0.01	0.03	0.03	0.02
	-0.01	0.03	0.01	0.02	0.01	0.02
	0.00	0.02	0.01	0.04	0.01	0.07
	0.01	0.00	0.01	0.02	0.03	0.02
	0.01	0.06	0.05	0.01	-0.01	0.05
	0.02	0.02	0.04	-0.01	0.02	0.02
	0.02	0.01	0.00	0.02	0.03	0.01
Min	-0.01	-0.01	0.00	-0.01	-0.01	-0.01
Max	0.03	0.06	0.05	0.04	0.03	0.08
Std Dev	0.01	0.02	0.02	0.02	0.01	0.03
Average	0.01	0.02	0.02	0.02	0.01	0.03

Part number	1326029-8 (704900-1)					
Product Name	2.8mm Male					
Wire Size	12 AWG					
Requirement	Max $\Delta R < 0.33 \text{ m}\Omega$					
Crimp Height	0.067		0.069		0.071	
Plating	Sn-Pb	Lead Free	Sn-Pb	Lead Free	Sn-Pb	Lead Free
	0.03	0.03	0.06	0.04	0.05	0.05
	0.12	0.01	0.04	0.03	0.02	0.06
	0.00	0.05	0.03	0.14	0.02	0.09
	0.09	0.14	0.02	0.09	0.07	0.09
	0.04	0.00	0.03	0.00	0.07	0.07
	0.04	0.00	0.03	0.02	0.02	0.03
	0.02	0.02	0.05	0.06	0.04	0.01
	0.07	0.04	0.01	0.00	0.06	0.03
	0.08	0.08	0.00	0.04	0.10	0.03
	0.05	0.13	0.03	0.03	0.08	0.04
Min	0.00	0.00	0.00	0.00	0.02	0.01
Max	0.12	0.14	0.06	0.14	0.10	0.09
Std Dev	0.04	0.05	0.02	0.04	0.03	0.03
Average	0.05	0.05	0.03	0.05	0.05	0.05

Part number	638174-1					
Product Name	Category 1, Male					
Wire Size	1.0 mm2					
Requirement	Max $\Delta R < 0.33 \text{ m}\Omega$					
Crimp Height	0.05		0.052		0.054	
Plating	Sn-Pb	Lead Free	Sn-Pb	Lead Free	Sn-Pb	Lead Free
	0.01	0.06	0.04	0.09	-0.02	0.13
	0.06	0.02	0.07	0.01	-0.02	0.00
	0.01	0.04	0.01	0.06	0.04	0.05
	0.03	-0.03	0.03	0.04	0.07	0.04
	0.02	-0.01	0.06	0.06	0.03	0.03
	-0.01	0.06	0.00	0.06	0.04	0.07
	0.01	0.07	0.01	-0.07	-0.03	0.11
	0.06	0.06	0.00	0.03	-0.07	0.10
	0.03	0.11	0.15	0.05	0.02	0.08
	0.00	0.01	0.01	0.00	-0.03	0.15
Min	-0.01	-0.03	0.00	-0.07	-0.07	0.00
Max	0.06	0.11	0.15	0.09	0.07	0.15
Std Dev	0.02	0.04	0.05	0.04	0.04	0.05
Average	0.02	0.04	0.04	0.03	0.00	0.08

Part number	638078-1					
Product Name	HDSF Pins, Size 16					
Wire Size	18 AWG					
Requirement	Max $\Delta R < 0.33 \text{ m}\Omega$					
Crimp Height	0.052		0.054		0.056	
Plating	Sn-Pb	Lead Free	Sn-Pb	Lead Free	Sn-Pb	Lead Free
	0.03	0.05	0.05	0.03	0.04	0.09
	0.06	0.01	-0.03	0.02	0.01	0.11
	0.07	0.01	-0.01	0.04	-0.02	0.10
	0.03	0.00	0.04	-0.02	-0.01	0.07
	0.07	0.00	0.03	0.02	0.16	0.01
	0.02	-0.01	0.04	-0.01	0.04	0.05
	0.05	0.00	0.01	0.04	0.00	0.02
	0.03	0.04	0.03	0.05	0.02	0.02
	0.03	0.03	0.05	0.03	0.01	0.02
	0.01	0.01	0.01	0.01	0.02	0.02
Min	0.01	-0.01	-0.03	-0.02	-0.02	0.01
Max	0.07	0.05	0.05	0.05	0.16	0.11
Std Dev	0.02	0.02	0.03	0.02	0.05	0.04
Average	0.04	0.01	0.02	0.02	0.03	0.05

Part number	770520-3					
Product Name	AMP Seal, Female					
Wire Size	18 AWG					
Requirement	Max $\Delta R < 0.33 \text{ m}\Omega$					
Crimp Height	0.048		0.05		0.052	
Plating	Sn-Pb	Lead Free	Sn-Pb	Lead Free	Sn-Pb	Lead Free
	0.00	0.03	0.01	0.02	0.03	0.04
	0.03	0.04	-0.03	0.03	0.01	-0.02
	-0.01	0.04	-0.03	-0.01	0.00	0.01
	0.00	0.01	0.00	-0.01	0.03	0.06
	-0.01	0.05	0.00	0.01	-0.02	-0.01
	-0.03	-0.01	0.00	0.00	0.01	-0.02
	0.01	-0.04	0.00	0.01	0.00	-0.05
	0.01	-0.02	0.01	0.02	-0.01	-0.02
	-0.01	-0.02	-0.01	0.03	-0.01	-0.02
	0.00	-0.03	0.02	0.00	0.02	-0.04
Min	-0.03	-0.04	-0.03	-0.01	-0.02	-0.05
Max	0.03	0.05	0.02	0.03	0.03	0.06
Std Dev	0.02	0.03	0.02	0.01	0.02	0.03
Average	0.00	0.01	0.00	0.01	0.01	-0.01

Conclusions:

Delta R between Sn and SnPb subgroups within a contact system is consistent. In some cases the average resistance change is slightly higher in SnPb plated crimp barrels and in other cases the opposite is true. To put this performance in perspective, the maximum average delta R is only 0.16 milliohms after being subjected to the aggressive environmental sequence. Appendix 1 shows the results of the statistical analysis. These results indicate that tin performance is statistically equivalent to tin-lead.

This data further reinforces the historical performance of Sn plated contact systems and provides additional data to prove that the conversion of SnPb to Sn plating in the crimp barrels has no impact on product performance.

Appendix 1. Data compilation from statistical analysis. Prob>.05 indicates tests are statistically equal.

