

Report EL-2005-03-009 CR
Evaluation of Repairability, FCI Lead Free AIRMAX VS® Receptacle Connectors
Rev. B
2006 May 08

PURPOSE:

Lead free AIRMAX VS® receptacle connectors were tested to assess mechanical performance of the matte tin plated compliant pins. Results were evaluated by comparison with product specifications. Testing included measurement of insertion and retention forces and evaluation of plated through hole (PTH) integrity during connector repair (3 connectors). These results are applicable to all FCI connectors with eye-of-needle (EON) style compliant sections on press fit (PF) pins fabricated from approximately 0.2 mm thick basis metal for application in printed wiring board (PWB) holes of approximately 0.5 mm nominal diameter.

CONCLUSIONS:

The lead-free test samples met the specified requirements for all tested quantities (insertion force, retention force, PTH deformation, and remaining PTH copper thickness).

SAMPLE DESCRIPTION:

Test sample identity is given in table 1.

Table 1. Identity of Submitted Samples

	Quantity	Description	Part Number	Lot	PF Plating	Received
1 st	200	AIRMAX VS® Rcpt	10016537-101LF	Y05084, Y05085 EPR 2592	Sn / Ni	2005 Mar 02

The plating on the compliant section of the lead free press fit pins is 0.5 micrometer to 1.5 micrometers of pure matte tin over 0.5 micrometer to 3 micrometers of nickel.

The lead-free product was tested in each of three (3) PTH sizes (minimum, nominal, and maximum) in PWBs with each of four (4) finishes (a total of 12 sample sets) as listed in table 2.

Table 2. Identity of Sample Sets

	PWB Finish	PTH Hole Size
1	Tin-Lead	Minimum
2	Copper / OSP	
3	Tin (Immersion)	
4	Silver (Immersion)	
5	Tin-Lead	Nominal
6	Copper / OSP	
7	Tin (Immersion)	
8	Silver (Immersion)	
9	Tin-Lead	Maximum
10	Copper / OSP	
11	Tin (Immersion)	
12	Silver (Immersion)	

REFERENCE DOCUMENTS:

Pertinent documents are listed in table 3.

Table 3. Reference Documents

Document ID	Title	Rev. Level (Date)
IEC 60352-5	Solderless connections – Part 5: Press-in connections – General requirements, test methods and practical guidance	Ed. 2.1 (2003 Dec)
FCI GS-12-239	Product Spec., AIRMAX VS® Connector System, press-fit products	A (2004 Oct 08)
FCI GS-20-035	Application Spec., AIRMAX VS® Connector System, press-fit products	A (2004 Oct 08)

TEST SEQUENCE:

The tests were applied in general accord with test groups A and B of IEC 60352-5, per sections 5.3.2.2 and 5.3.2.3, as listed in table 4

Table 4. Sequence of Applied Tests by Test Group

Test Description	Condition	Sequence
		Group A
		Connector Repair
		5 Connectors / Sample Set
Insertion Force Measurement	Initial	1
Retention Force Measurement	1st	2
Repair: Insertion	2nd	3
Retention	2nd	4
Insertion	3rd	5
Microsectioning	Transverse	6 (10 Pins)
PTH Deformation		7 (10 Pins)
Remaining Cu Thickness		8 (10 Pins)
Microsectioning	Longitudinal	9 (10 Pins)
PTH Axial Damage		10 (10 Pins)
Retention Force Measurement	Final (3rd)	11 (Remaining Connectors)

TEST PROCEDURES:

Insertion Force

The force required to insert the press fit pins of the connector into the test board was measured in accordance with IEC 60352-5, section 5.2.2.2, using a tensile/compression test instrument. Insertion proceeded under machine control by pushing the connector into the PWB at a rate of 12 millimeters per minute using connector insertion tool 430277-001. The pin insertion force was taken as the maximum force encountered during connector insertion divided by the number of pins per connector.

Retention Force

The force required to remove the press fit pins from the test board was measured in accordance with IEC 60352-5, section 5.2.2.3, using a tensile/compression test instrument. Removal proceeded under machine control by applying compressive force to the tip of the press fit pins and pushing at a rate of 12 millimeters per minute using connector removal tool 430282. The pin retention force was taken as the maximum force encountered during connector removal divided by the number of pins per connector. A minimum recovery period of 24 hours was allowed after pin insertion prior to insertion force measurement.

Repair

Repair (replacement) of connectors was conducted in accordance with IEC 60352-5, section 5.2.2.6.

Microsectioning and PTH Integrity

Microsectioning was done in accordance with IEC 60352-5, section 5.2.2.5. Deformation of the plated through hole was measured on a transverse section through the press fit region 0.3 mm from the top (entry side) surface of the PWB after the third (3rd) insertion (with the press fit pin in the PTH) in accordance with IEC 60352-5, section 5.2.2.5.1. Minimum remaining PTH copper thickness was measured on the same section in accordance with IEC 60352-5, section 5.2.2.5.1. Axial damage of the PTH (e.g., cracks or voids in the copper) was evaluated qualitatively on a longitudinal section through the press fit pin in accordance with IEC 60352-5, section 5.2.2.5.2; quantitative measurements were performed only if trace connection deformation was observed.

REQUIREMENTS:

The requirements were taken from FCI product specification GS-12-239 as listed in table 5.

Table 5. Requirements

Test	Item	Value
Insertion Force Measurement	Maximum Insertion Force	25 N
Retention Force Measurement	Minimum Retention Force	3 N
PTH Deformation	Maximum Radial Deformation	50 μm
	Maximum Average Radial Deformation	37.5 μm
Remaining PTH Copper Thickness	Minimum Cu Thickness	7.5 μm

TEST RESULTS:

Test Group A (Connectors)

The results of force measurements on assembled connectors are summarized in tables 6 through 8 and displayed graphically in figures 1 through 3. The results of maximum PTH deformation measurement are summarized in table 9 and displayed graphically in figure 4. The results of minimum remaining PTH copper thickness are summarized in table 10 and displayed graphically in figure 5.

Table 6. Initial Insertion Force (Connectors)

PTH Size	Minimum				Nominal				Maximum			
	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
PWB Finish												
Count	4	4	4	4	4	4	4	4	4	4	4	4
	[Average Measured Force / Pin] / N											
Average	16.07	15.81	16.96	17.64	13.36	11.62	12.75	16.45	10.71	7.68	9.37	16.05
Std Dev	0.39	0.41	0.35	0.25	0.81	0.27	0.57	0.46	0.74	1.24	0.37	4.72
Minimum	15.66	15.24	16.73	17.29	12.63	11.24	11.95	15.84	9.99	6.70	9.02	12.48
Maximum	16.46	16.22	17.47	17.88	14.32	11.86	13.29	16.93	11.71	9.28	9.85	22.54

Table 7. 1st Retention Force (Connectors)

PTH Size	Minimum				Nominal				Maximum			
	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
PWB Finish												
Count	4	4	4	4	4	4	4	4	4	4	4	4
	[Average Measured Force / Pin] / N											
Average	7.45	7.08	8.17	6.46	6.92	6.57	7.76	8.30	6.11	6.09	7.32	7.36
Std Dev	0.17	0.11	0.13	1.04	0.26	0.11	0.07	0.10	0.13	0.59	0.11	0.72
Minimum	7.24	6.94	8.10	5.58	6.70	6.41	7.68	8.16	5.99	5.58	7.18	6.61
Maximum	7.59	7.21	8.36	7.86	7.18	6.64	7.83	8.39	6.29	6.76	7.41	8.18

Table 8. Final Retention Force (Connectors)

PTH Size	Minimum				Nominal				Maximum			
	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
PWB Finish												
Count	3	3	3	3	3	3	3	3	3	3	3	3
	[Average Measured Force / Pin] / N											
Average	8.82	8.46	8.37	8.45	8.22	8.39	8.68	8.22	7.41	7.66	7.76	6.05
Std Dev	0.37	0.07	0.11	0.36	0.22	0.09	0.18	0.48	0.46	1.34	0.26	1.13
Minimum	8.51	8.39	8.24	8.10	7.98	8.30	8.51	7.68	7.03	6.14	7.47	4.92
Maximum	9.22	8.54	8.45	8.81	8.39	8.48	8.87	8.60	7.92	8.66	7.98	7.18

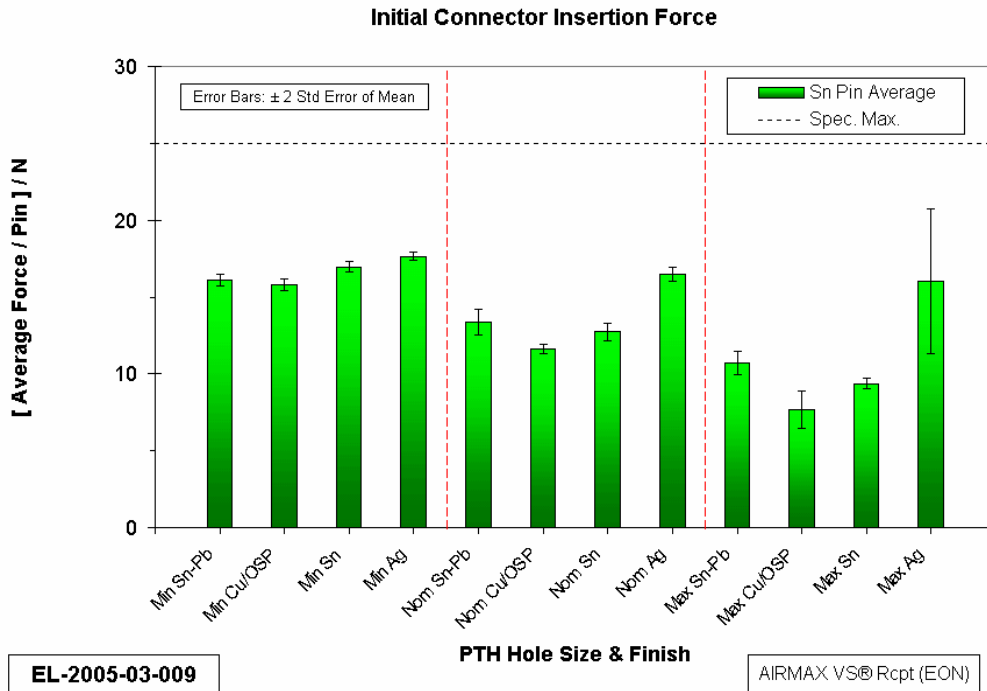


Figure 1. Initial Insertion Force (Connectors)

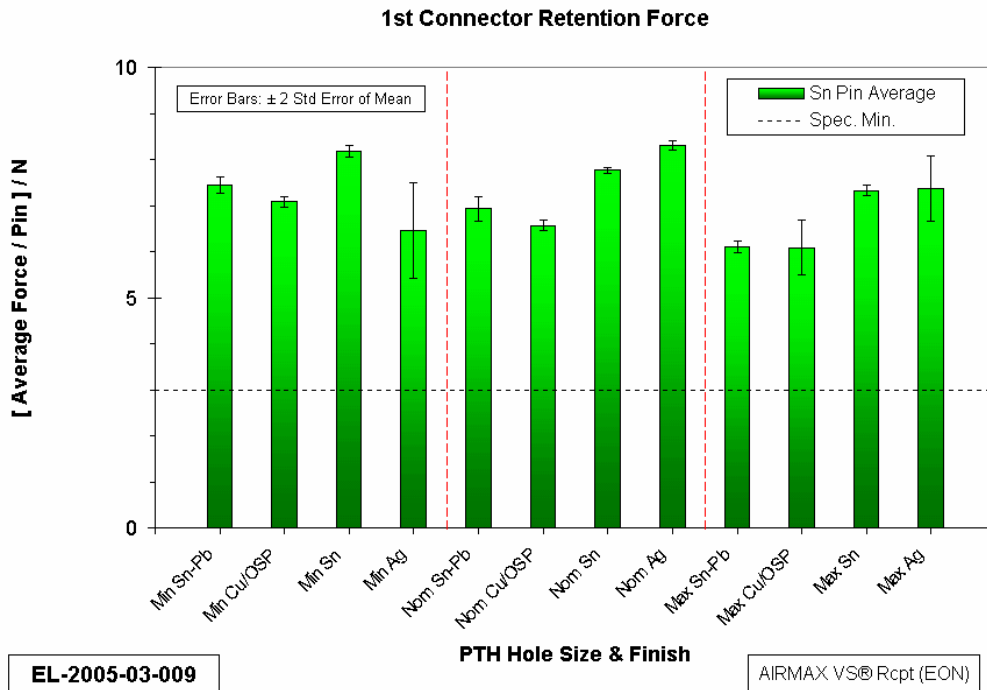


Figure 2. 1st Retention Force (Connectors)

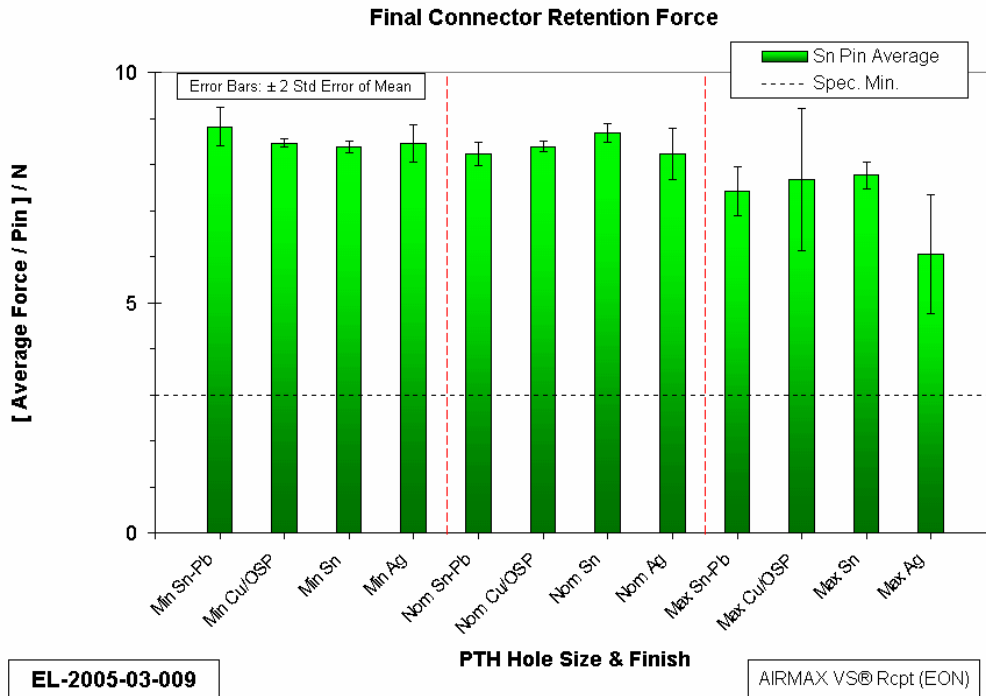


Figure 3. Final Retention Force (Connectors)

Table 9. Maximum PTH Deformation

PTH Size	Minimum				Nominal				Maximum			
	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
Count	10	10	10	10	10	10	10	10	10	10	10	10
Measured Maximum PTH Deformation / μm												
Average	1.0	0.5	4.1	4.1	0.0	0.0	2.0	1.3	0.0	0.5	4.8	3.8
Std Dev	1.8	1.6	6.2	2.1	0.0	0.0	2.6	1.3	0.0	1.6	4.2	2.5
Minimum	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Maximum	5.1	5.1	20.3	5.1	0.0	0.0	5.1	2.5	0.0	5.1	10.2	7.6

Table 10. Minimum Remaining PTH Copper Thickness

PTH Size	Minimum				Nominal				Maximum			
	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
Count	10	10	10	10	10	10	10	10	10	10	10	10
Measured Minimum Remaining PTH Copper Thickness / μm												
Average	21.5	19.7	15.3	18.9	27.3	24.9	16.8	28.2	30.3	14.4	19.8	14.7
Std Dev	3.0	3.4	4.7	5.0	3.3	2.6	1.3	3.6	2.1	2.6	3.6	5.9
Minimum	17.6	14.1	11.6	9.8	22.4	19.9	15.0	22.2	27.3	10.6	15.0	7.7
Maximum	26.0	24.5	27.4	26.6	32.2	28.4	19.2	33.4	33.4	18.1	25.3	22.7

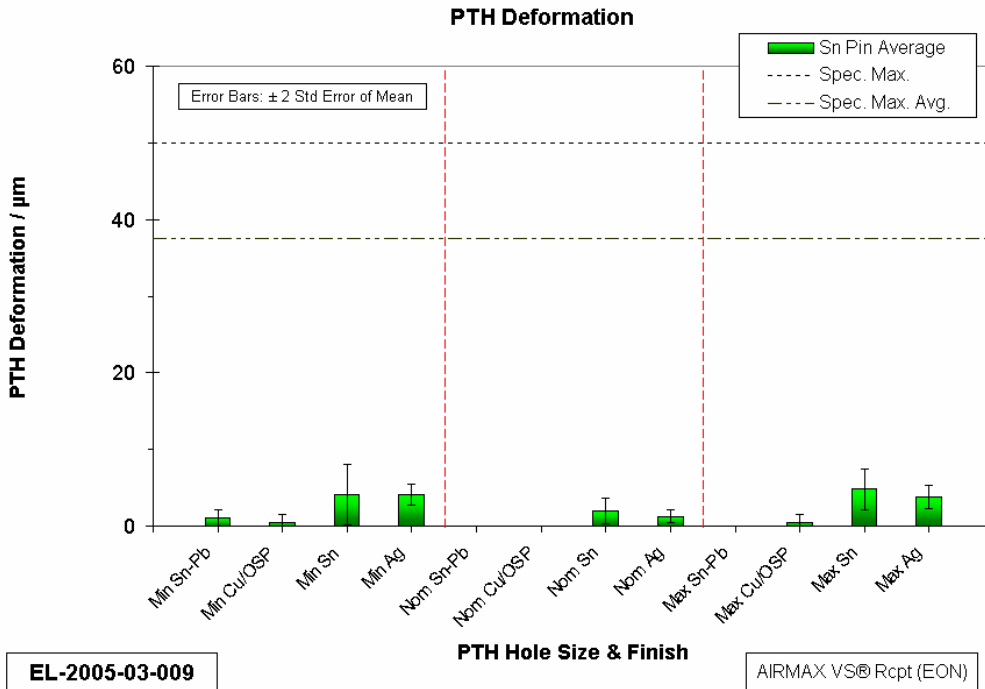


Figure 4. Maximum PTH Deformation

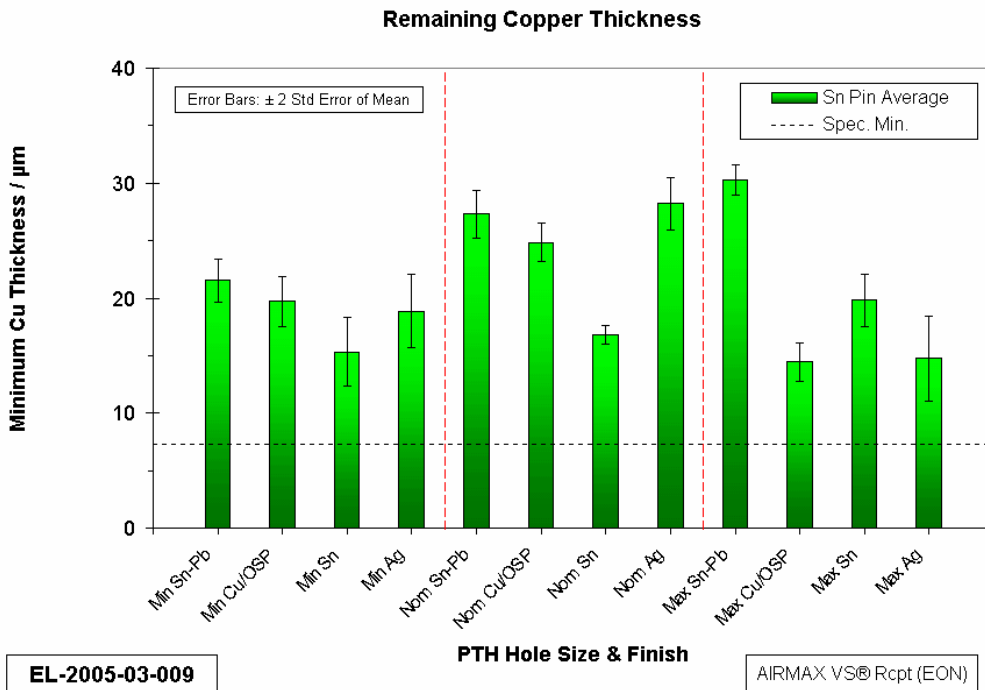


Figure 5. Minimum Remaining PTH Copper Thickness

EQUIPMENT:

Item Description	Manufacturer (Model)	Equip. ID #	Cal. Due Date
Microscope	Bausch & Lomb (StereoZoom 5)	VG6620	Not Calibrated
Tensile/Compression Tester	Instron (Model 1122, SN 5112)	VG6463	2005 Jul
Load Cell	Instron (1000 lb, SN 1978)	VG6449	2005 Jul
Calibration Mass	Instron (10 lb, #1)	VG6253	2005 Aug
Calibration Mass	Instron (10 lb, #2)	VG6254	2005 Aug
Micrometer	Mitutoyo (M825-1", SN 193-211)	VG6809	2006 Jan
Metallographic Microscope	Reichert-Jung (Polyvar-MET, SN 392265)	VG7398	Not Calibrated
Digital Camera	Diagnostics Instruments (Insight Model 3.2.0)	VG7749	Not Calibrated
Stage Micrometer	SPI (2266)	VG7648	2010 Oct
Comparator	Nikon (Profile Projector Model V-12)	VG6416	2005 Jun

REVISION RECORD

Rev. #	Revision Date	Page(s)	Description
-	2005 Apr 26	All	Original Issue
A	2006 Apr 03	1	Updated Corporate Logo
B	2006 May 08	1	Repositioned Corporate Logo