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Report EL-2005-10-030 CR

Evaluation of Repairability, FCI Lead Free METRAL® Converged Headers

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PURPOSE:

Lead free METRAL® headers were tested to assess mechanical performance of the matte tin plated compliant pins. Results were evaluated by comparison with product specification. Testing included measurement of insertion and retention forces and evaluation of plated through hole (PTH) integrity during connector repair (3 pins). These results are applicable to all FCI connectors with eye-of-needle (EON) style compliant sections on press fit (PF) pins fabricated from approximately 0.5 mm thick basis metal for application in printed wiring board (PWB) holes of approximately 0.7 mm nominal diameter.

CONCLUSIONS:

The lead-free test samples met the specified requirements for 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
666	METRAL® Header Assembly	89006-116LF	EPR V-2637	Sn / Ni	2005 Jul 15

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 press fit product was tested in each of two (2) PTH sizes (minimum and maximum) in PWBs with each of four (4) finishes (a total of 6 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	
4	Silver	
5	Tin-Lead	Maximum
6	Copper / OSP	
7	Tin	
8	Silver	

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-12-180	Product Specification, Converged METRAL® Header	D (2006 Feb 06)
FCI BUS-20-073	Application Specification, Application Guide for Converged METRAL® Vertical Press Fit Signal Headers and Shrouds	C (2005 Oct 31)
FCI BUS-02-057	Document and Drafting Standard, Plating Selection Guidelines	C (2000 Sep 05)

TEST SEQUENCE:

The tests were applied in general accord with test groups A and B (combined) 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

		Sequence
		Groups A & B (Combined)
		Connector Repair
Test Description	**Condition**	**5 Connectors**
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, Min. PTH Only)
PTH Deformation		7 (10 Pins, Min. PTH Only)
Remaining Cu Thickness		8 (10 Pins, Min. PTH Only)
Microsectioning	**Longitudinal**	9 (10 Pins, Min. PTH Only)
PTH Axial Damage		10 (10 Pins, Min. PTH Only)
Retention Force Measurement	**Final (3rd)**	11 (Remaining Connectors)

TEST PROCEDURES:

Insertion Force
The force required to insert 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 pins in the header assembly into the PWB to the nominal depth at a rate of 12 millimeters per minute using connector insertion tool 415685-1, Rev. C, with the PWB supported on a slotted fixture (to allow clearance for pin tips protruding through the PWB). The pin insertion force was taken as the maximum force encountered during pin insertion divided by the number of pins in the connector.

Retention Force
The force required to remove the connector 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 tips of the press fit pins and pushing at a rate of 12 millimeters per minute. All pins were removed simultaneously using a multiple pin removal fixture, 416321-005, with the body of the bottom of the mating cavity of the connector housing supported on a slotted fixture (to allow clearance for pin removal). The pin retention force was taken as the maximum force encountered during pin removal divided by the number of pins in the connector. A minimum recovery period of 24 hours was allowed after pin insertion prior to retention force measurement.

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

Microsectioning and PTH Integrity
Microsectioning was performed on pins in minimum size PTHs in accordance with IEC 60352-5, sections 5.2.2.5, 5.3.2.1.1, and 5.3.2.2. 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-12-180, Rev. D, as listed in table 5.

Table 5. Requirements

Test	Item	Value
Insertion Force Measurement	Maximum Insertion Force	65 Newtons per Pin in Header
Retention Force Measurement	Minimum Retention Force	20 Newtons per Pin in Header
PTH Deformation	Maximum Radial Deformation	50.8 micrometers 38.1 µm Max. Avg. (10 PTHs)
Remaining PTH Copper Thickness	Minimum Cu Thickness	7.62 µm Min. Avg. (10 PTHs)

TEST RESULTS:

Connector Repair

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				Maximum			
PWB Finish	Sn-Pb [1]	Cu/OSP [2]	Sn [3]	Ag [4]	Sn-Pb	Cu/OSP	Sn	Ag
Count	5	5	5	5	5	5	5	5
	[Average Measured Force / Pin] / Newton							
Average	60.9	41.3	50.2	54.3	52.3	28.4	41.0	50.1
Std Dev	1.6	3.0	3.1	1.4	0.4	0.1	1.4	1.7
Minimum	58.7	37.5	47.3	53.1	51.9	28.3	40.0	47.9
Maximum	63.2	44.5	55.2	55.9	52.9	28.6	43.3	51.7

(1) HASL (Hot Air Solder Leveling)
(2) Organic Solderability Preservative on Copper
(3) Immersion Tin
(4) Immersion Silver

Table 7. 1st Retention Force (Connectors)

PTH Size	Minimum				Maximum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
Count	5	5	5	5	5	5	5	5
	[Average Measured Force / Pin] / Newton							
Average	32.9	26.3	29.9	27.8	37.3	25.2	33.9	34.3
Std Dev	2.5	1.2	1.3	0.5	1.9	0.7	1.6	4.3
Minimum	30.2	24.9	28.0	27.4	35.1	24.6	32.8	31.4
Maximum	36.6	27.3	31.4	28.6	39.3	26.1	36.3	41.8

Table 8. Final Retention Force (Connectors)

PTH Size	Minimum				Maximum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
Count	5	5	5	5	5	5	5	5
	[Average Measured Force / Pin] / Newton							
Average	33.6	31.7	34.9	25.5	35.8	34.5	36.9	28.3
Std Dev	0.7	1.2	1.8	1.5	0.6	0.5	2.4	0.7
Minimum	32.9	30.4	33.5	23.9	35.3	34.0	34.4	27.7
Maximum	34.3	32.6	36.9	26.7	36.5	34.8	39.1	29.1

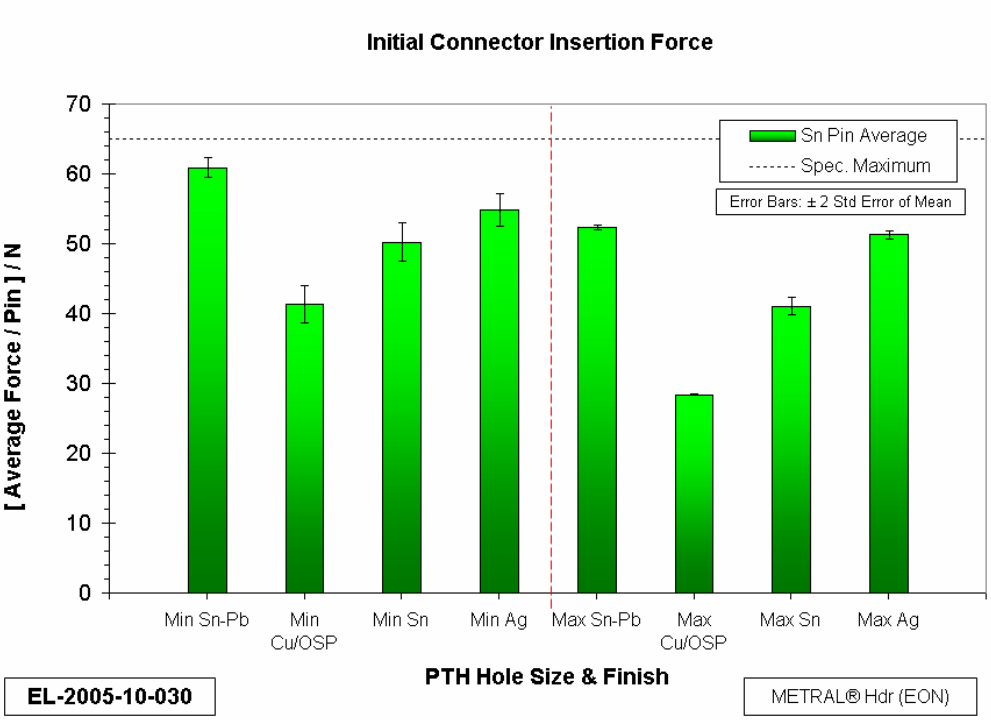

Figure 1. Initial Insertion Force (Connectors)

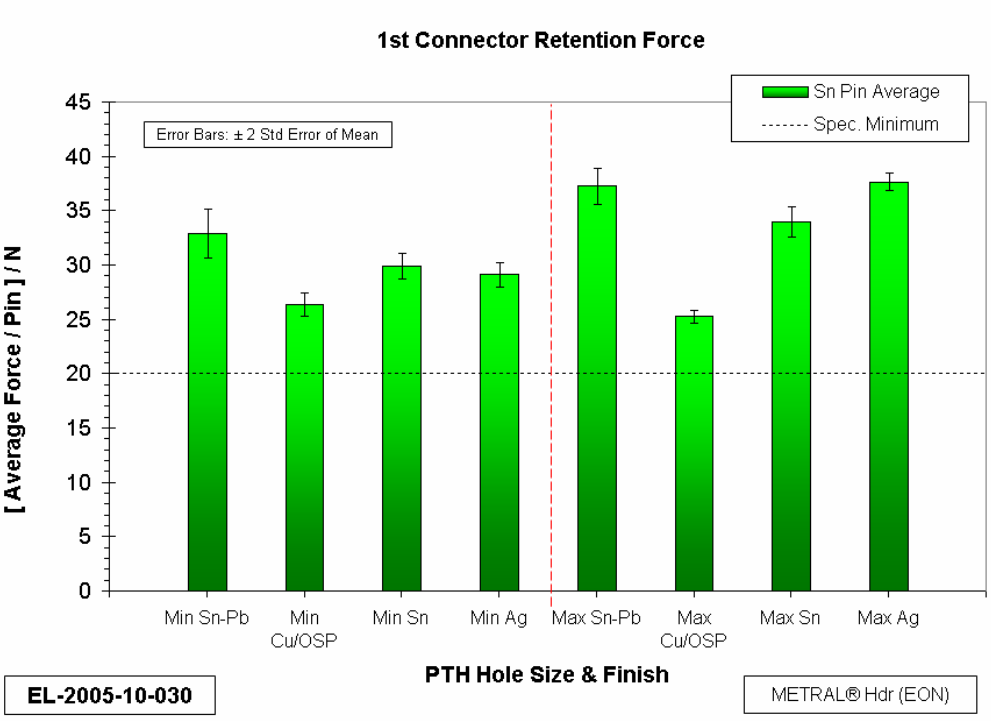

Figure 2. 1st Retention Force (Connectors)

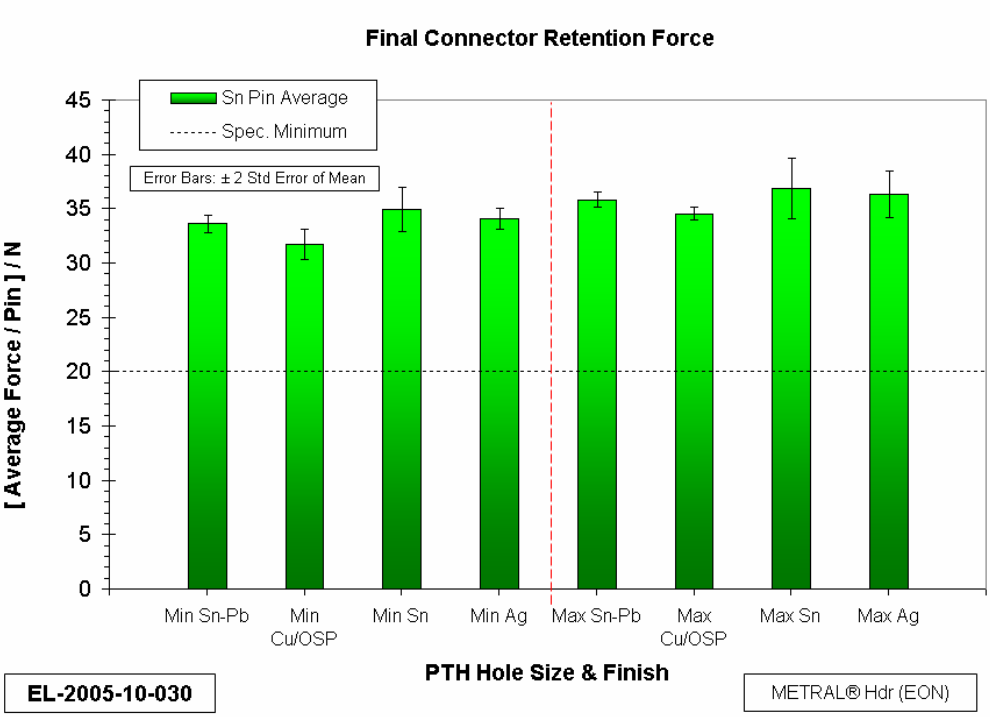

Figure 3. Final Retention Force (Connectors)

Table 9. Maximum PTH Deformation

PTH Size	Minimum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag
Count	10	10	10	10
	Measured Maximum PTH Deformation / micrometer			
Average	25.4	25.4	18.0	25.4
Std Dev	0.0	0.0	5.9	0.0
Minimum	25.4	25.4	12.7	25.4
Maximum	25.4	25.4	25.4	25.4

Table 10. Minimum Remaining PTH Copper Thickness

PTH Size	Minimum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag
Count	10	10	10	10
	Measured Minimum Remaining PTH Thickness / micrometer			
Average	33.3	20.5	31.3	39.6
Std Dev	5.4	4.5	4.9	5.3
Minimum	27.8	12.8	22.3	31.5
Maximum	45.9	26.8	39.9	46.6

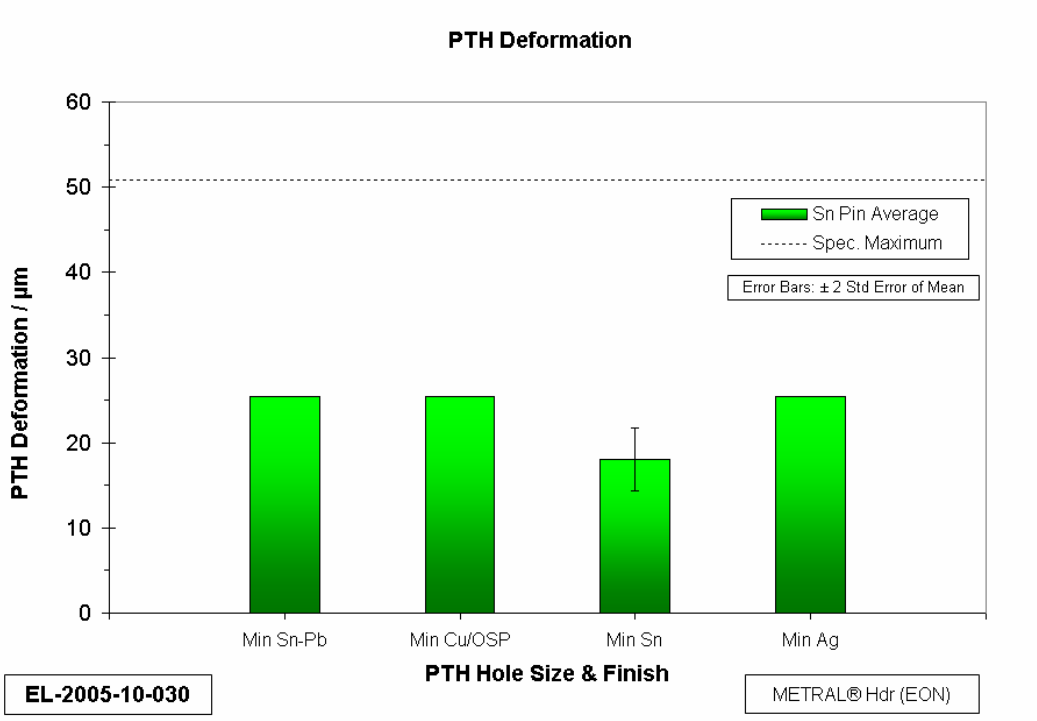

Figure 4. Maximum PTH Deformation

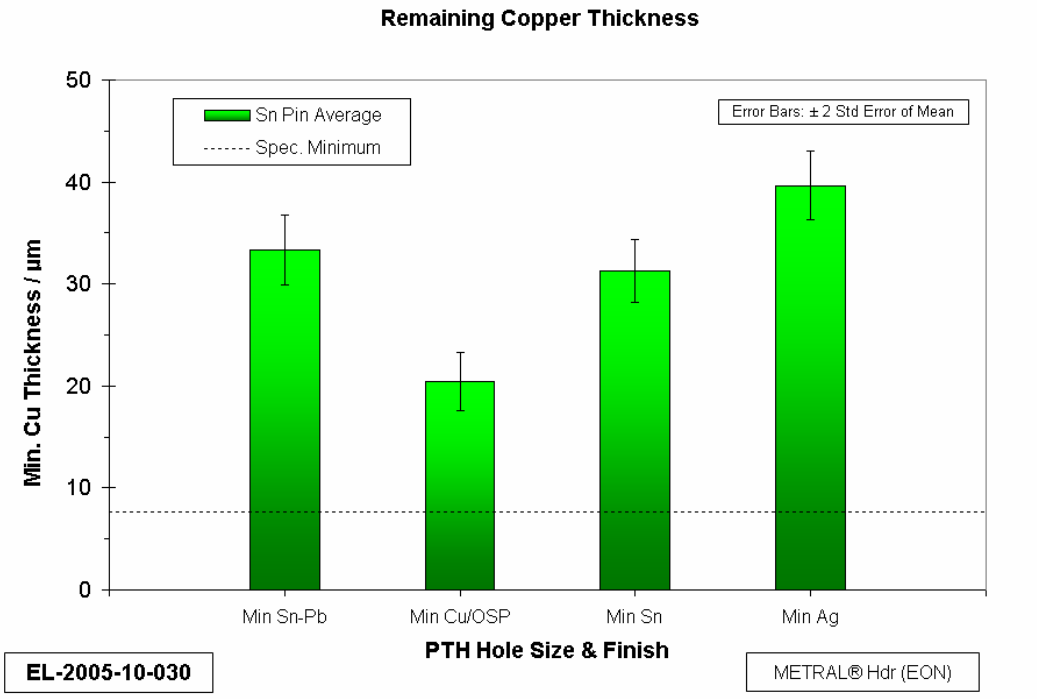

Figure 5. Minimum Remaining PTH Copper Thickness

EQUIPMENT:

Item Description	Manufacturer (Model)	Equip. ID #	Cal. Due Date
Microscope	Bausch & Lomb (StereoZoom 5)	VG6613	Not Calibrated
Tensile/Compression Tester	Instron (Model 1122, SN 4664)	VG6464	2006 Aug
Tensile/Compression Tester	Instron (Model 1122, SN 5013)	VG6461	2006 Aug
Load Cell	Instron (1000 lb, SN 1616)	VG6448	2006 Aug
Load Cell	Instron (1000 lb, SN 1978)	VG6449	2006 Aug
Load Cell	Instron (50 kg, SN 045)	VG6827	Cal. Before Use
Calibration Mass	Instron (1 av lb)	VG6258	2006 Aug
Calibration Mass	Instron (5 lb)	VG6255	2006 Aug
Calibration Mass	Instron (10 av lb, #3)	VG6251	2006 Aug
Calibration Mass	Instron (10 av lb #4)	VG6252	2006 Aug
Calibration Mass	Instron (20 lb, #2)	VG6843	2006 Aug
Calibration Mass	Instron (20 lb, #4)	VG6845	2006 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 Dec

REVISION RECORD

Rev. #	Revision Date	Page(s)	Description
–	2006 Feb 16	All	Original Issue