

**Report EL-2005-02-026 CR**  
Evaluation of Repairability, FCI Lead Free METRAL® 1000 Connectors  
Rev. C  
2006 Jun 01

**PURPOSE:**

Lead free METRAL® 1000 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 pins). These results are applicable to all FCI connectors with Baby-H 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**

Item	Quantity	Description	Part Number	Lot	PF Plating	Received
1	2500	METRAL® Signal Pins	55010-102LF	EPR V-2542	Sn / Ni	2005 Jan 20
2	287	METRAL® 1000 Connector	73983-1011LF	EPR V-2543	Sn / Ni	2005 Jan 20

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 three (3) finishes (a total of 6 sample sets) as listed in table 2.

In addition to signal pins, the header assemblies contain ground springs that have different press fit sections than the signal pins. Consequently, prior to testing, the ground springs were removed from the header assemblies to assure that the measured forces were indicative only of a single type of press fit interface (i.e., that of the lead free signal pins under test). For the majority of the testing (PWBs with tin-lead, Cu/OSP, and tin finish), the tested assemblies had six (6) rows of six (6) terminals each yielding a total of 36 terminals per connector. For testing in PWBs with silver finish, the grounding terminals (1 of 6 rows) were removed yielding a total of 30 terminals per connector.

**Table 2. Identity of Sample Sets**

	PWB Finish	PTH Hole Size
1	Tin-Lead	Minimum
2	Copper / OSP	
3	Immersion Tin	
4	Immersion Silver	
5	Tin-Lead	Maximum
6	Copper / OSP	
7	Immersion Tin	
8	Immersion 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-12-110	Product Specification, METRAL® 1000 Series – 5 Row and METRAL® 2000 Series – 5 Row	Rev. G (2005 Sep 14)
FCI GS-20-010	Application Specification, For 5-Row 1000 & 2000 Headers and Shrouds and 8-Row Std., 1000 & 2000 Headers and Shrouds	Rev. H (2005 Oct 21)

**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	Group B
		Connector Repair	Individual Pin Repair
		5 Connectors	20 Pins
Insertion Force Measurement	Initial	1	1
Retention Force Measurement	1 <sup>st</sup>	2	2
Repair:	Insertion	3	3
	Retention	4	4
	Insertion	5	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 (3 <sup>rd</sup> )	11 (Remaining Connectors)	6

## **TEST PROCEDURES:**

### **Insertion Force**

The force required to insert the press fit pin(s) 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 pin(s) into the PWB to the nominal depth at a rate of 12 millimeters per minute. For the headers, this was accomplished 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.

### **Retention Force**

The force required to remove the press fit pin(s) 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 pin(s) and pushing at a rate of 12 millimeters per minute. For the headers, 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. A minimum recovery period of 24 hours was allowed after pin insertion prior to insertion force measurement.

### **Repair**

Repair (replacement) of pins or connectors 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 (3<sup>rd</sup>) 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-12-110 as listed in table 5.

**Table 5. Requirements**

<b>Test</b>	<b>Item</b>	<b>Value</b>
<b>Insertion Force Measurement</b>	Maximum Insertion Force	100 Newtons for Individual Pin 130 Newtons/Pin for Pins in Header
<b>Retention Force Measurement</b>	Minimum Retention Force	20 Newtons
<b>PTH Deformation</b>	Maximum Radial Deformation	50 micrometers 37.5 µm Max. Avg. (10 PTHs)
<b>Remaining PTH Copper Thickness</b>	Minimum Cu Thickness	7.5 micrometers

## TEST RESULTS:

This testing was conducted under US Product Test Laboratory numbers EL-2006-02-026 (PWBs with tin-lead, copper/OSP, and tin finish) and EL-2006-02-026A (PWBs with silver finish).

### 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; all forces values are reported as force per terminal (measured force divided by the number of terminals in the tested assembly). 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			
	Sn-Pb <sup>(1)</sup>	Cu/OSP <sup>(2)</sup>	Sn <sup>(3)</sup>	Ag <sup>(4)</sup>	Sn-Pb	Cu/OSP	Sn	Ag
PWB Finish								
Count	5	5	5	5	5	5	5	5
	[ Average Measured Force / Pin ] / Newton							
Average	78.5	60.3	67.0	80.8	58.7	68.3	61.3	73.5
Std Dev	2.6	1.4	0.9	2.5	2.0	1.1	1.2	1.8
Minimum	76.4	58.6	66.0	77.7	57.1	67.6	59.3	70.6
Maximum	82.9	62.3	68.3	84.5	62.2	70.3	62.4	75.0

<sup>(1)</sup> HASL (Hot Air Solder Leveling)

<sup>(2)</sup> Organic Solderability Preservative on Copper

<sup>(3)</sup> Immersion Tin

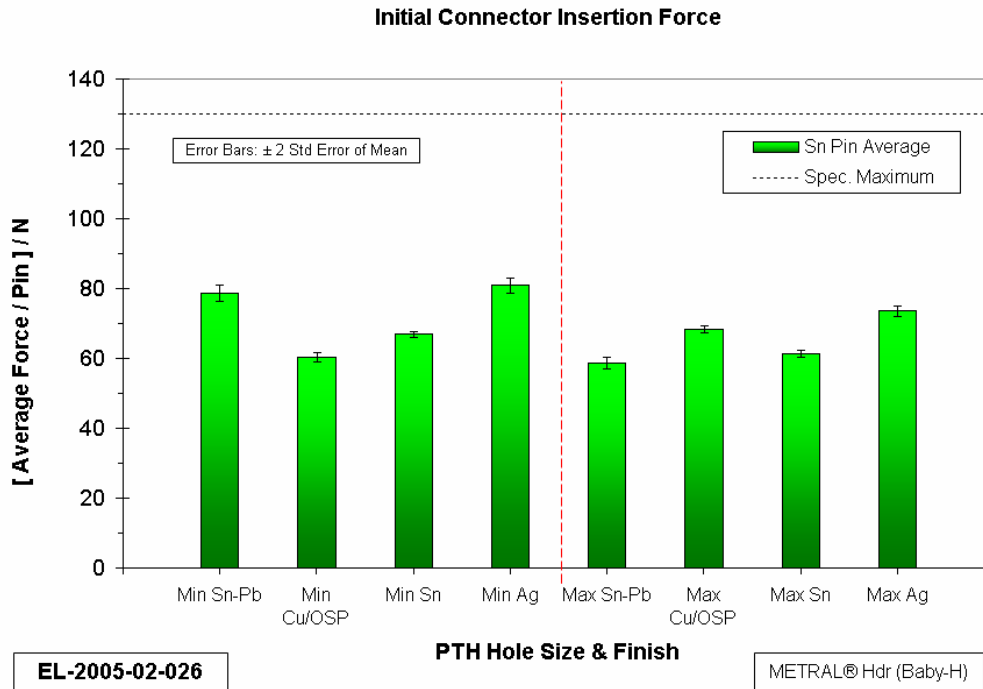
<sup>(4)</sup> Immersion Silver

**Table 7. 1<sup>st</sup> Retention Force (Connectors)**

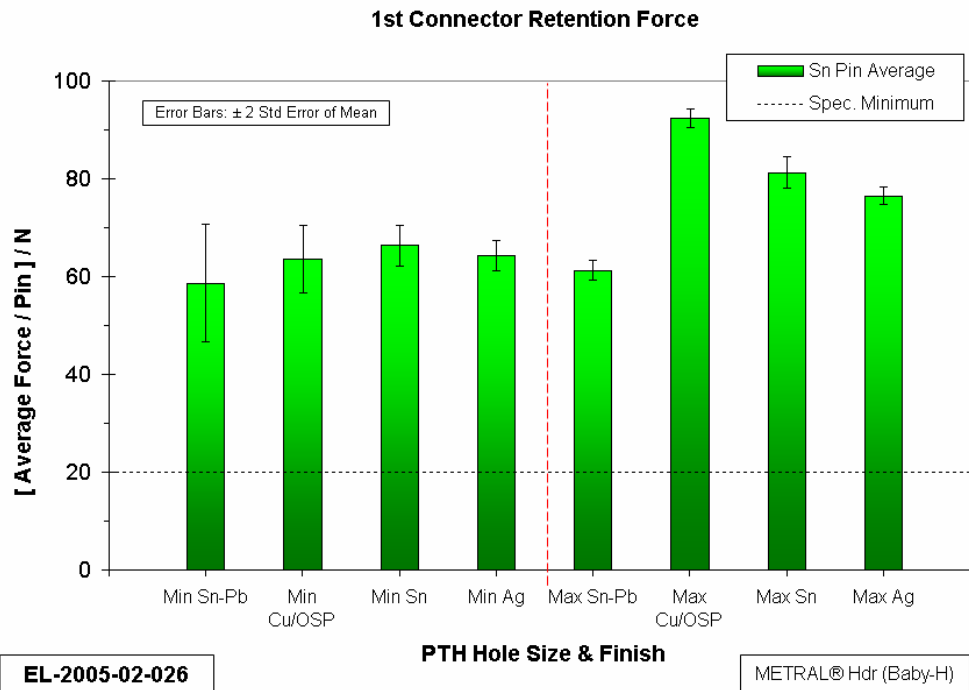
PTH Size	Minimum				Maximum			
	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
PWB Finish								
Count	5	5	5	5	5	5	5	5
	[ Average Measured Force / Pin ] / Newton							
Average	58.7	63.6	66.3	64.4	61.3	92.4	81.3	76.5
Std Dev	13.5	7.8	4.7	3.5	2.2	2.2	3.6	2.0
Minimum	34.6	54.2	62.8	60.8	58.4	89.6	74.9	73.2
Maximum	66.7	75.7	74.1	69.8	63.3	94.8	83.7	78.3

**Table 8. Final Retention Force (Connectors)**

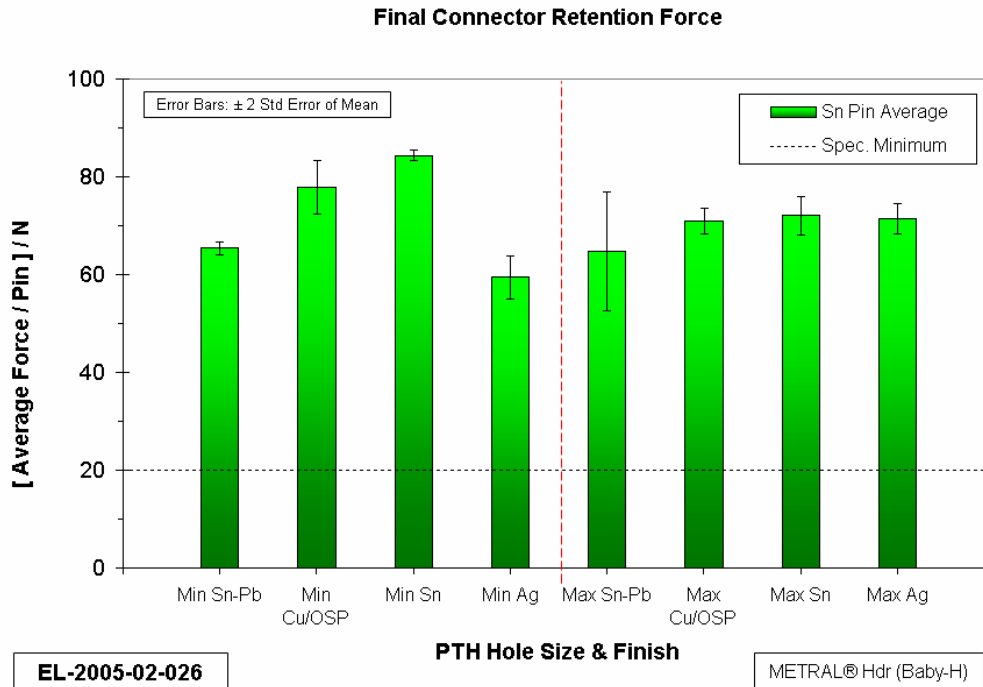
PTH Size	Minimum				Maximum			
	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
PWB Finish								
Count	2	2	2	3	2	2	2	3
	[ Average Measured Force / Pin ] / Newton							
Average	65.4	77.8	84.3	59.5	64.7	70.9	72.0	71.4
Std Dev	1.0	3.8	0.8	3.8	8.6	1.8	2.8	2.7
Minimum	64.7	75.1	83.8	55.5	58.7	69.6	70.1	69.2
Maximum	66.1	80.6	84.9	63.0	70.8	72.2	74.0	74.4



**Figure 1. Initial Insertion Force (Connectors)**



**Figure 2. 1<sup>st</sup> Retention Force (Connectors)**



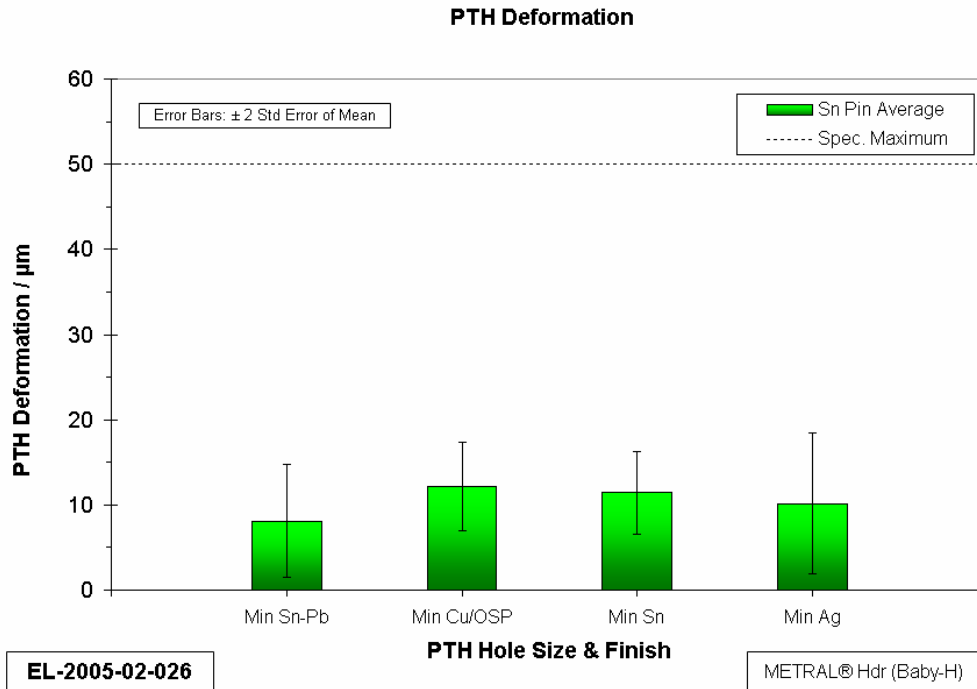
**Figure 3. Final Retention Force (Connectors)**

**Table 9. Maximum PTH Deformation**

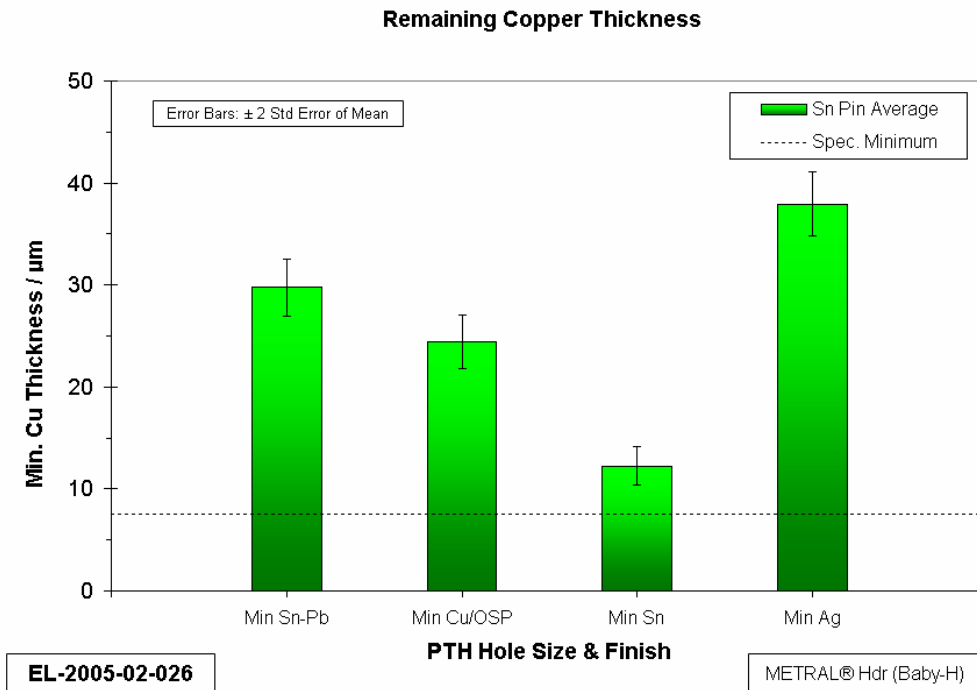
PTH Size	Minimum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag
Count	10	10	10	10
<b>Measured Maximum PTH Deformation / micrometer</b>				
Average	8.1	12.2	11.4	10.2
Std Dev	10.5	8.2	7.7	13.1
Minimum	0.0	0.0	0.0	0.0
Maximum	20.3	20.3	20.3	25.4

**Table 10. Minimum Remaining PTH Copper Thickness**

PTH Size	Minimum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag
Count	10	10	10	10
<b>Measured Minimum Remaining PTH Thickness / micrometer</b>				
Average	29.8	24.4	12.3	37.9
Std Dev	4.5	4.1	3.0	4.9
Minimum	24.1	18.2	7.5	31.6
Maximum	35.7	30.9	17.0	45.9



**Figure 4. Maximum PTH Deformation**



**Figure 5. Minimum Remaining PTH Copper Thickness**

## Test Group B (Individual Pins)

The results of force measurement on individual pins are summarized in tables 11 through 13 and displayed graphically in figures 6 through 8.

**Table 11. Initial Insertion Force (Individual Pins)**

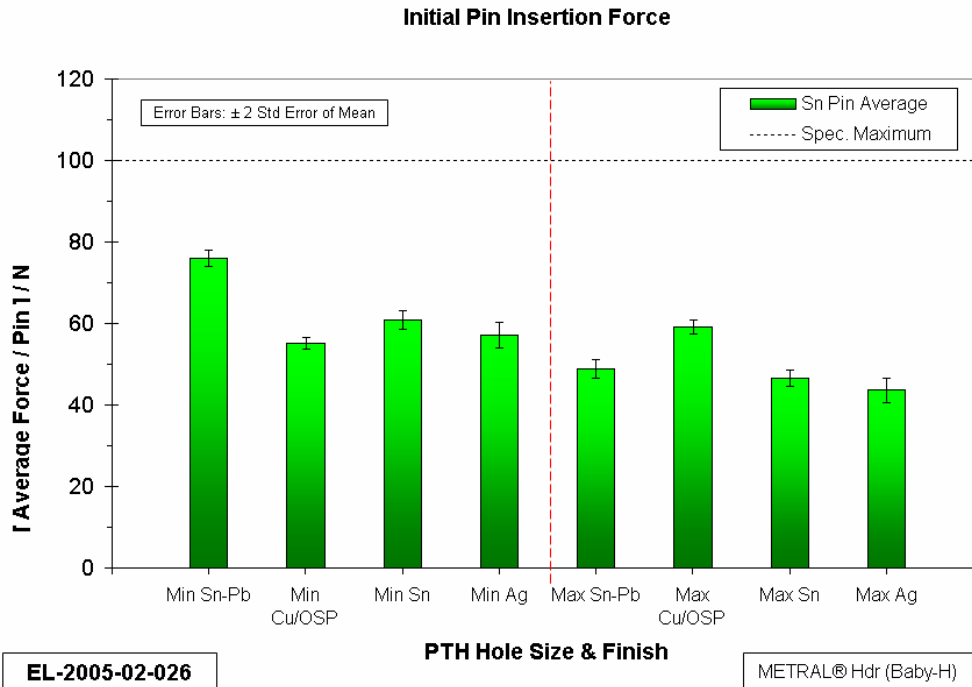
PTH Size	Minimum				Maximum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
Count	20	20	20	20	20	20	20	20
	[ Measured Force / Pin ] / Newton							
Average	76.1	55.3	60.8	57.1	48.8	59.2	46.5	43.6
Std Dev	4.5	3.2	5.0	7.1	5.2	3.6	4.5	6.6
Minimum	68.9	46.3	49.8	49.4	40.3	50.7	39.6	34.3
Maximum	80.7	58.9	69.4	70.3	59.2	64.1	59.2	56.5

**Table 12. 1st Retention Force (Individual Pins)**

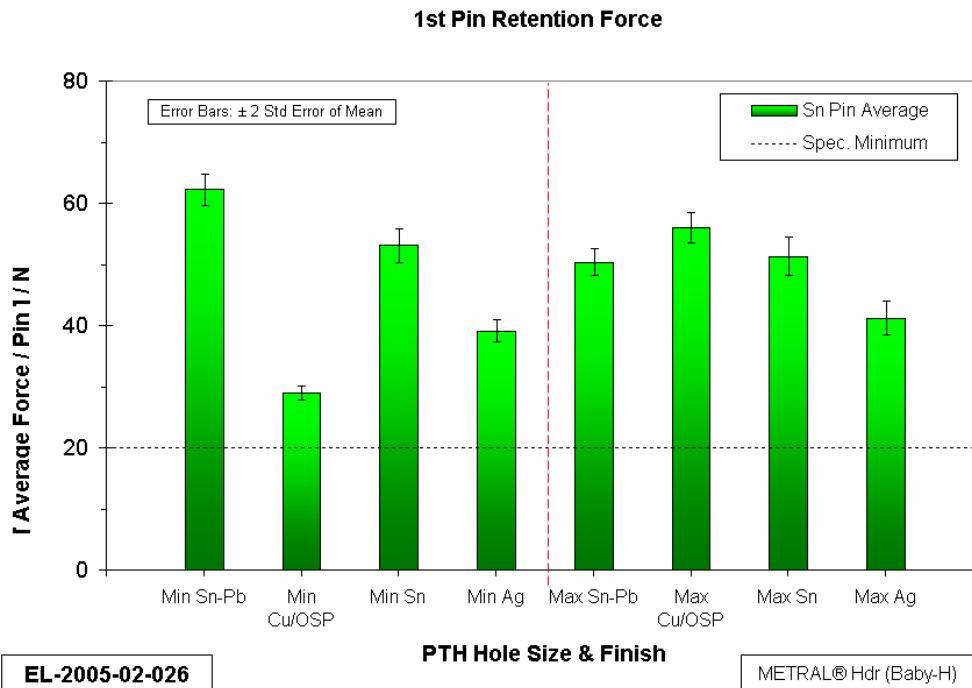
PTH Size	Minimum				Maximum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
Count	20	20	20	20	20	20	20	20
	[ Measured Force / Pin ] / Newton							
Average	62.2	28.9	53.1	39.1	50.4	56.0	51.3	41.2
Std Dev	5.7	2.5	6.1	3.9	4.9	5.6	7.0	6.1
Minimum	47.6	24.9	39.6	30.2	42.0	43.6	43.1	32.0
Maximum	73.4	32.7	63.6	45.8	60.5	67.6	65.2	52.5

**Table 13. Final Retention Force (Individual Pins)**

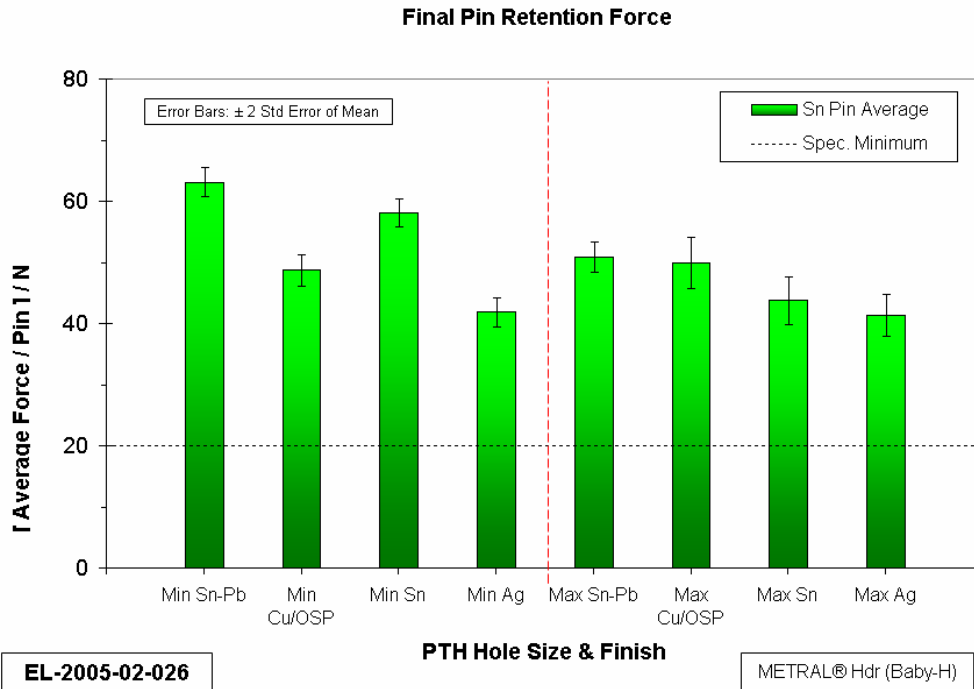
PTH Size	Minimum				Maximum			
PWB Finish	Sn-Pb	Cu/OSP	Sn	Ag	Sn-Pb	Cu/OSP	Sn	Ag
Count	20	20	20	20	20	20	20	20
	[ Measured Force / Pin ] / Newton							
Average	63.1	48.7	58.1	41.8	50.8	49.9	43.7	41.4
Std Dev	5.4	5.8	5.2	5.4	5.6	9.4	8.8	7.7
Minimum	53.6	38.3	46.7	32.0	40.5	33.4	32.0	25.4
Maximum	73.4	59.4	67.6	50.3	61.8	63.2	61.4	56.0



**Figure 6. Initial Insertion Force (Individual Pins)**



**Figure 7. 1<sup>st</sup> Retention Force (Individual Pins)**



**Figure 8. Final Retention Force (Individual Pins)**

**EQUIPMENT:**

Item Description	Manufacturer (Model)	Equip. ID	Cal. Date	Cal. Due
Tensile/Compression Tester	Instron (Model 1122, SN 4664)	VG6464	2004 Jun 30	2005 Jul
Tensile/Compression Tester	Instron (Model 1122, SN 5112)	VG6463	2005 Aug 03	2006 Aug
Load Cell	Instron (1000 lb, SN 1693)	VG6452	2004 Jun 30	2005 Jul
Load Cell	Instron (1000 lb, SN 1616)	VG6448	2005 Aug 02	2006 Aug
Calibration Mass	Instron (20 lb, #1)	VG6842	2004 Aug 06	2005 Aug
Calibration Mass	Instron (20 lb, #2)	VG6843	2004 Aug 06	2005 Aug
Calibration Mass	Instron (20 lb, #3)	VG6844	2004 Aug 06	2005 Aug
Calibration Mass	Instron (20 lb, #4)	VG6845	2004 Aug 06	2005 Aug
Calibration Mass	Instron (20 lb, #5)	VG6846	2004 Aug 06	2005 Aug
Calibration Mass	Instron (10 lb, #1)	VG6253	2004 Aug 06	2005 Aug
Calibration Mass	Instron (10 lb, #1)	VG6253	2005 Sep 02	2006 Sep
Calibration Mass	Instron (10 lb, #2)	VG6254	2004 Aug 06	2005 Aug
Calibration Mass	Instron (10 lb, #2)	VG6254	2005 Sep 02	2006 Sep
Calibration Mass	Instron (10 lb, #3)	VG6251	2004 Aug 06	2005 Aug
Calibration Mass	Instron (5 lb)	VG6255	2004 Aug 06	2005 Aug
Climate Monitor	Fisher Scientific (SN 230011236)	VG7813	2003 Apr	2005 Apr
Climate Monitor	Fisher Scientific (11-661-7D, SN 51018205)	VG7960	2005 Mar	2007 Mar
Micrometer	Mitutoyo (M825-1", SN 193-211)	VG6809	2005 Jan	2006 Jan
Micrometer	Mitutoyo (M825-1", SN 193-211)	VG6809	2006 Jan	2007 Jan
Metallographic Microscope	Reichert-Jung (Polyvar-MET, SN 392265)	VG7398	Not Calibrated	NA
Digital Camera	Diagnostics Instruments (Insight Model 3.2.0)	VG7749	Not Calibrated	NA
Stage Micrometer	SPI (2266)	VG7648	2000 Oct 12	2010 Oct
Optical Comparator	Nikon (Profile Projector Model V-12)	VG6416	2004 Dec 14	2005 Jun
Optical Comparator	Nikon (Profile Projector Model V-12)	VG6416	2005 Dec 06	2006 Jun

REVISION RECORD

<b>Rev. #</b>	<b>Revision Date</b>	<b>Page(s)</b>	<b>Description</b>
-	2005 Jun 10	All	Original Issue
A	2006 Apr 03	1	Updated Corporate Logo
B	2006 May 08	1	Repositioned Corporate Logo
C	2006 Jun 01	All	Incorporated Results for Ag Plated PWBs from EL-2006-02-026A