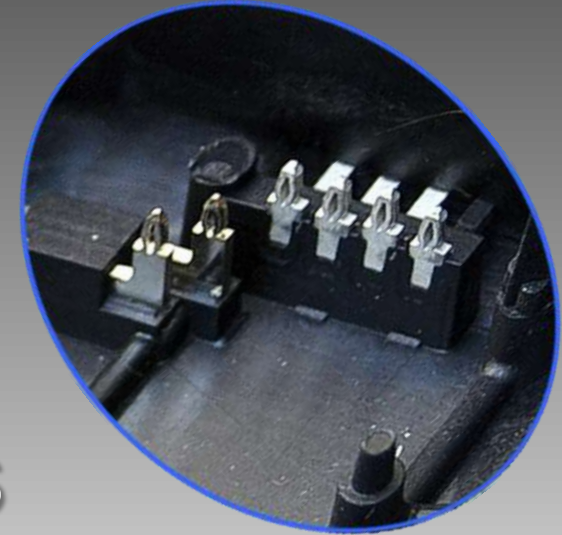


Adapting Press-Fit Connection Technology for Electronic Modules in Harsh Environments.



By

**Joseph Lynch – Director of Advanced Product Engineering
– Interplex Industries Inc, USA.**

**Andy Longford – Consultant – PandA Europe, UK
& Business Development - Interplex Engineered Products**

**InterplexTM
Industries, Inc.**

Global Solutions for Complex Parts and Assemblies

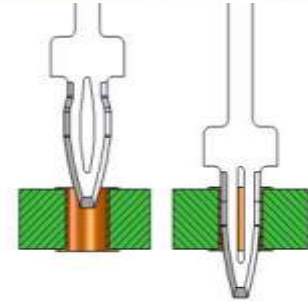
Introduction

- Interplex
- Press-fit basics
- Connections in HE
- Testing
- Approvals
- Module development
- Applications

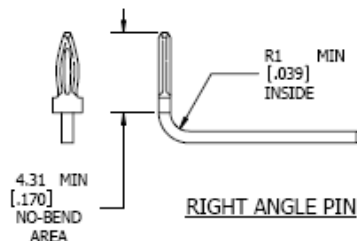
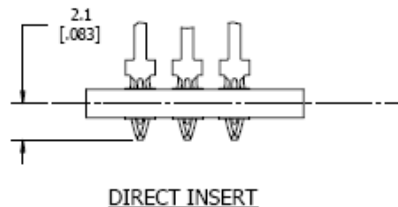


Press fit basics ...

- Function of Press-Fit Technology
- Telecom to Automotive Adoption
- Core design types
 - 0.25mm, 0.64mm, 0.80mm
- Plating Types, & options
- Applications



					
EYE THICKNESS (mm)	0.25	0.4	0.64	0.8	1.0



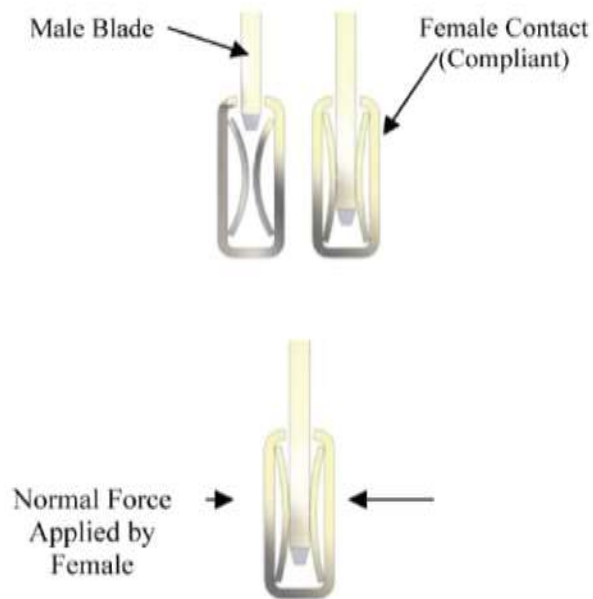
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Press fit technology ...

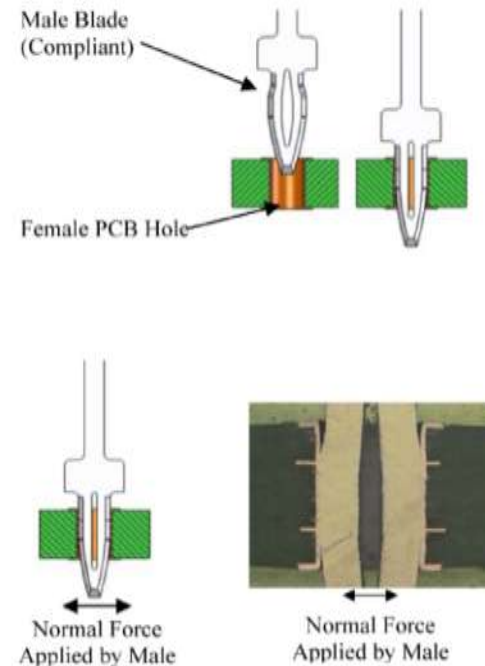
Solder Less Interconnect System to Printed Circuit Cards

Typical Male/ Female Interconnect



Interconnection Force
***Grams ***

Typical Press-Fit Male/ Female Interconnect



Interconnection Force
*** Kilograms ***

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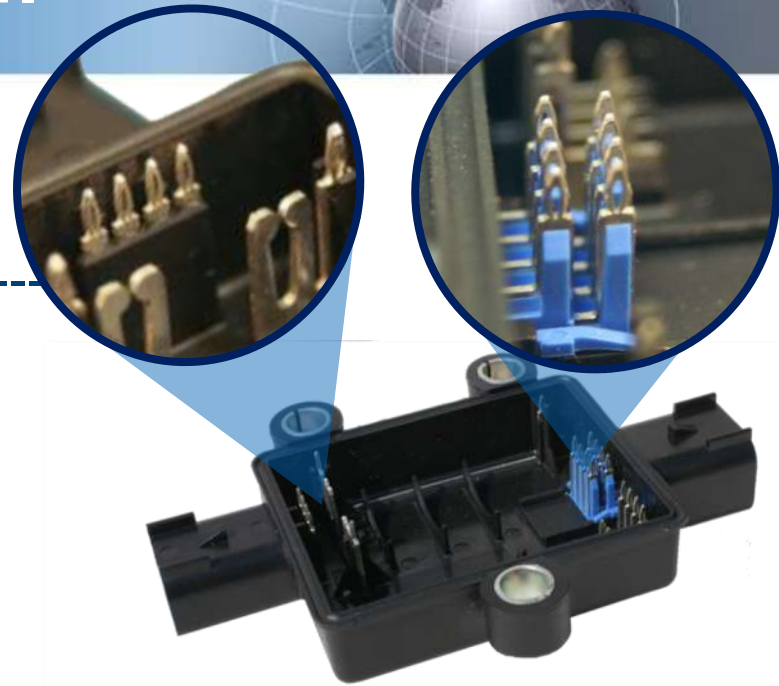
Press fit connections

Require:

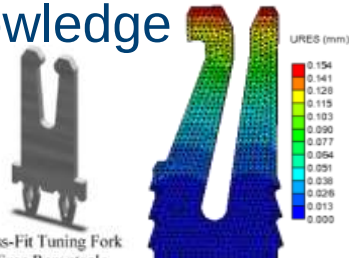
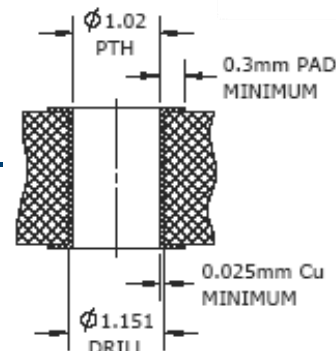
- Complex Plastics-----
- Press fit Terminals
 - IDC
 - Eyelet
 - Tuning Fork
 - Clamp



EYE OF THE NEEDLE



- PCB Hole Construction Controls-----
- Application Knowledge



Press-Fit Tuning Fork
Fuse Receptacle
(.81mm) Thick

HiTEN 2009 - Oxford

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Telecom to Automotive

Telecom

Temp to 85 °C

Vibration –None

Retention Force- 8N

Rework –Yes

Plating-2 to3 Microns

Contact Resistance- 4.0mΩ Max



Automotive

Temp to 150 °C

Vibration- 12G-three Axis(In Temp)

Retention -20N to 40N

Rework - no

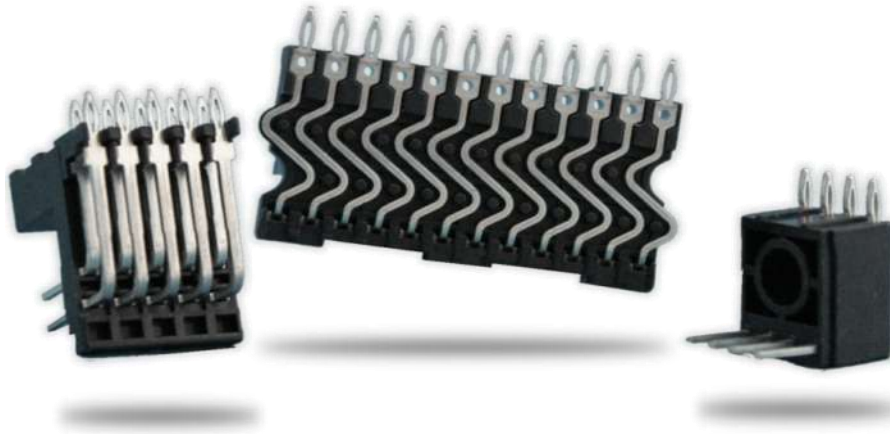
Plating- 0.4 to 1.2 Microns

Contact Resistance- 0.5mΩ Max

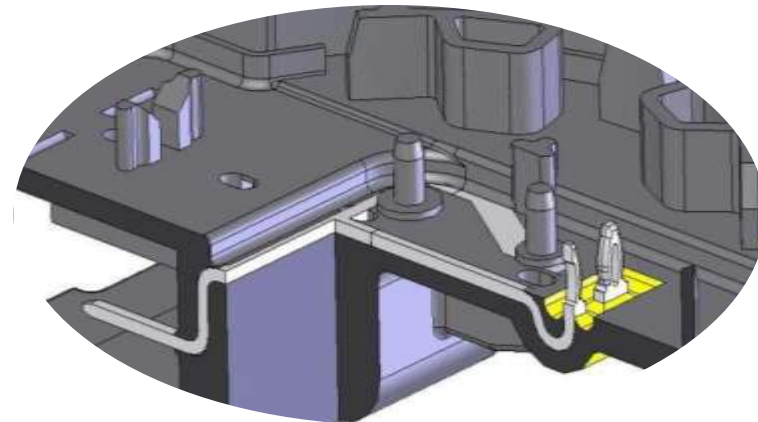
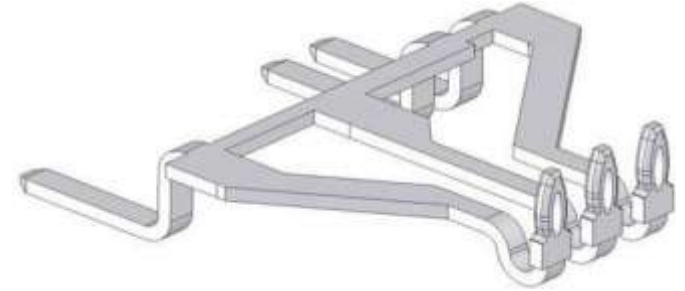


Press fit connections ...

Complex Press fit Stampings

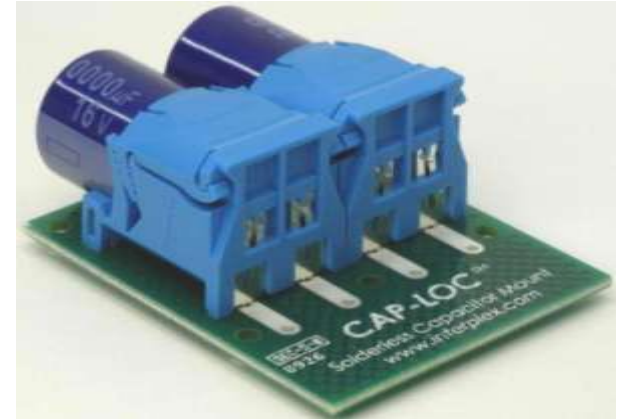


Complex Plastic holders



Harsh Environment interconnections ...

- **Mechanical Requirements- Kilograms**
- **Temperature Requirements vs. Material Selections**
 - (125°C, 150°C, @ 175 °C)
- **Electrical requirements**
 - Milliohm resistance (0.5MΩ)
 - Typical current requirements
 - per eye & thickness
 - Per Application Size
- **Application requirements**
 - Energy
 - Transport
- **Testing requirements**
 - resulting example data will shown in the Testing
- **PCB Constructions and Types**
 - Hole size, plating PCB copper
- **Applications Failure Modes- (Printed Circuit Card)**



Capacitor Holders

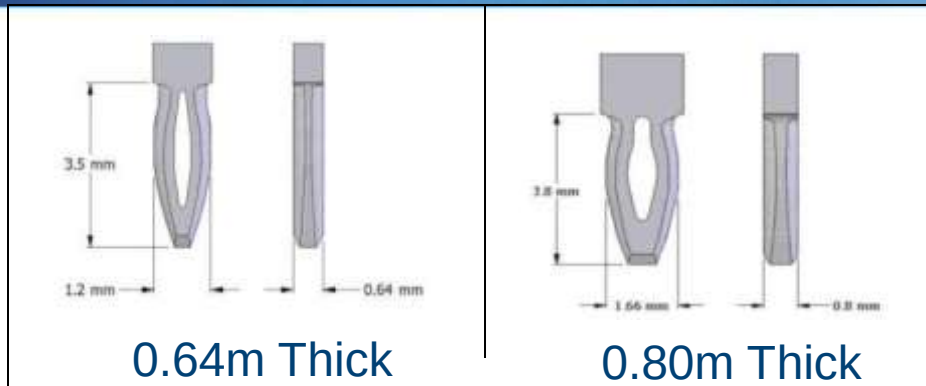


Inverters

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HE interconnections



Press-Fit Style- Eye of the needle

- Solderless Technology design to meet the Automotive/ Transportation Requirements
- Qualified to 125° C and 150° C Operational temperatures and moving to 175° C
- Requirements defined by IEC, EIA and SAE.
- Designs validated for both 0.64mm and 0.80mm thick press-fit sections - Other sizes being Introduced (.4mm,1.0mm,1.5mm)
- High conductive material options - Power Applications 30%,40% & 80% IACS
- Compatible with Various PCB Plating Types



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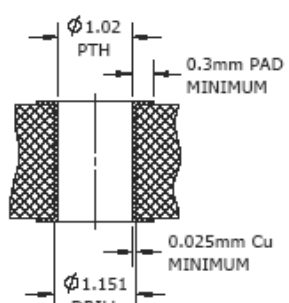
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HE interconnections

- **PCB hole sizes:**

- 0.64mm & 0.80mm press-fit to fit into (Nominal) 1.016mm and 1.486mm respectively.

		mm	in
REQUIRED PCB HOLE CONSTRUCTION 1.57 (.062) THICK FR-4	DRILL	Ø 1.151 ± 0.025	Ø .0453 ± .0010
	COPPER THICKNESS	0.025 MIN	.0010 MIN
	FINAL IMMERSION PLATED HOLE DIAMETER	Ø 1.020 ± 0.076	Ø .0400 ± .0030
PIN INSERTION FORCE: 100 N (22.5 lbf) MAXIMUM PIN RETENTION FORCE: 20 N (4.5 lbf) MINIMUM SEE 0.64 PRESS-FIT TEST REPORT SUMMARY FOR TYPICAL VALUES			



Ø 1.02 PTH

0.3mm PAD MINIMUM

0.025mm Cu MINIMUM

Ø 1.151 DRILL



- **PCB Types :**

- $T_g > 150^\circ \text{C}$
- Plated Through Holes (PTH)- Single & Multilayer
- PCB Platings: Tin, Silver, Gold, OSP
- PCB Construction FR-4 1.57mm thick & up

- **Terminal Plating:** 1 Micron-Tin plating in Press-Fit Zone

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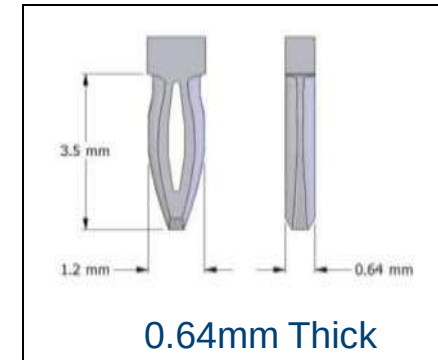
HE interconnections

Primary Drivers for Materials & Options:

Temperature • Conductivity • Bend Radius

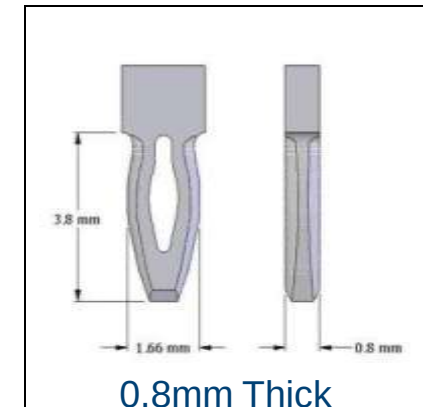
.64mm Thick:

- 125 °C Primary Alloy: CuSn5 15% IACS
- 150 °C alloy : 7025 CuNiSi- 40% IACS
- Conductive Alloy: Special Brass:(CuZnSnNiFeP) 30% IACS



.80mm Thick:

- 125 °C Primary Alloy: Special Brass:(CuZnSnNiFeP) 30% IACS
- 150 °C alloy : 7025 CuNiSi – 40% IACS
- Conductive Alloy:(CuCrAgFeTiSi) 80% IACS

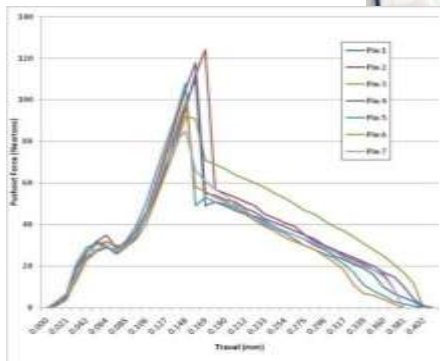


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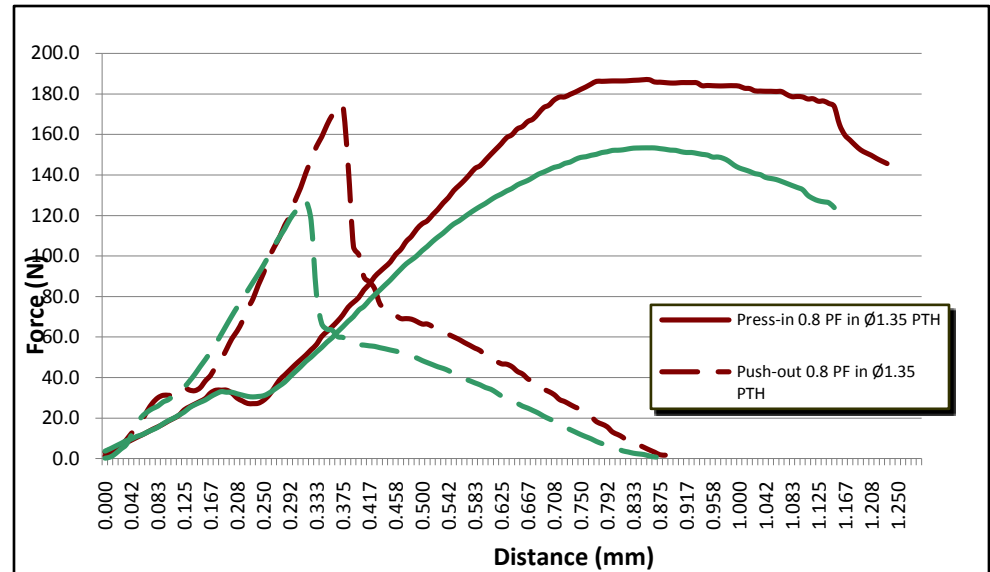
Testing

- Tests criteria
- Test sequence & requirements
- Data and results

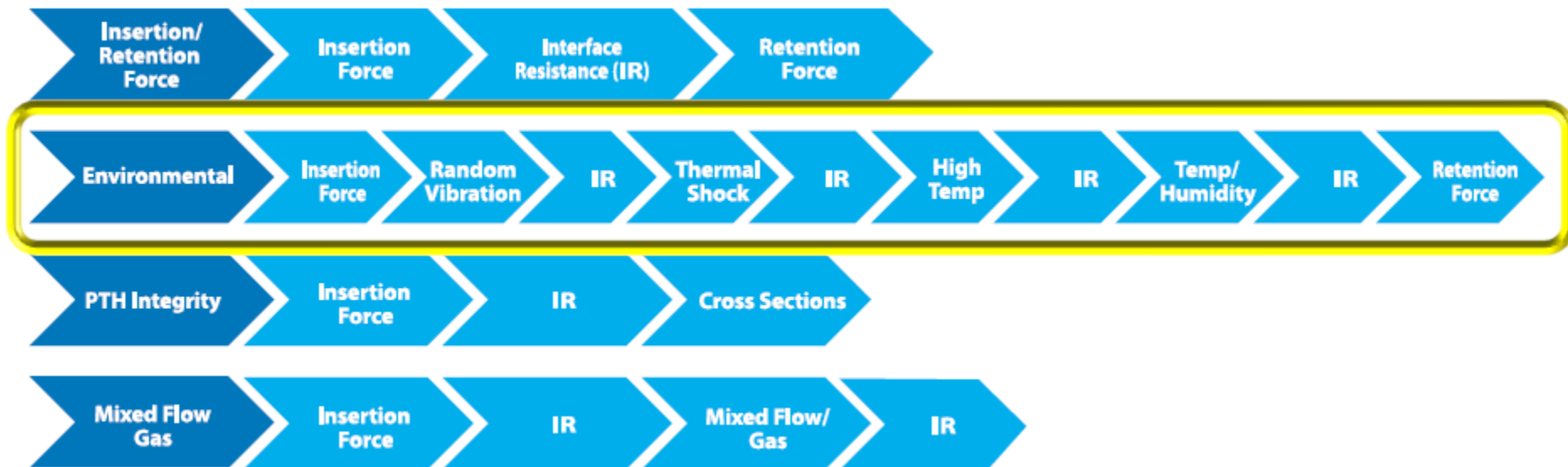


Test Criteria

- Insertion force and retention force
- Vibration in Temperature
- Thermal shock
- High temperature exposure
- Temperature and humidity cycling
- Mixed flowing 4 Gas test
- Current carrying capacity
- Plated through hole integrity



Test Sequence & Requirements



- Contact Resistance.5mΩ Max
- 20N retention for .64mm
- 60N retention for .80mm
- IEC-60352-5 Plated Through Hole Integrity
- No Visual Damage



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Thermal requirements

- Materials and testing up to 150 °C
- Testing Continuing to 175 °C
- Random Vibration in Temperature- For Chassis mount

Cabin • Underhood • Near Engine • On Engine

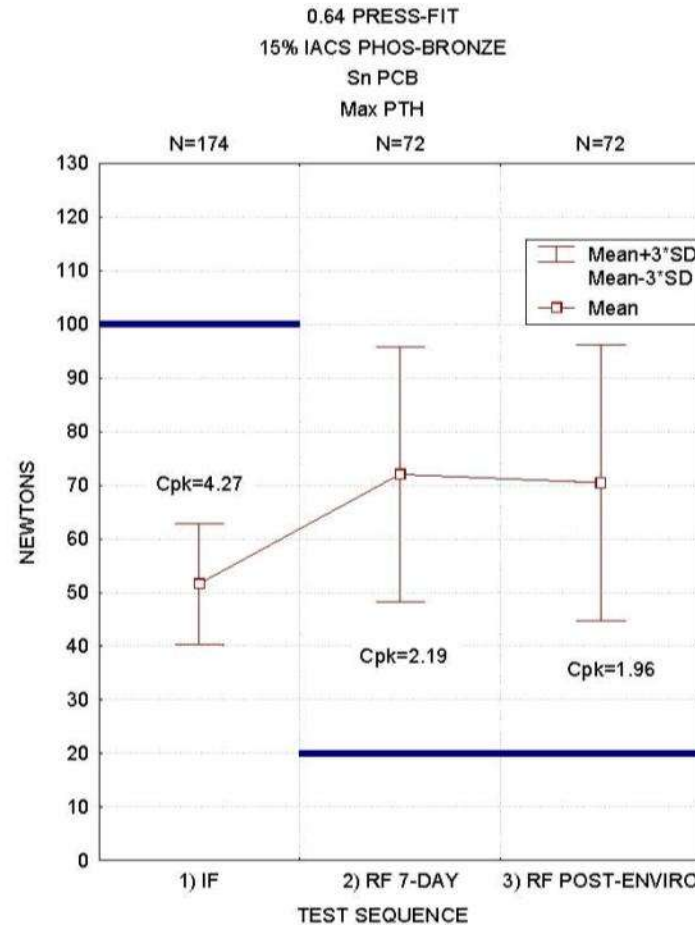
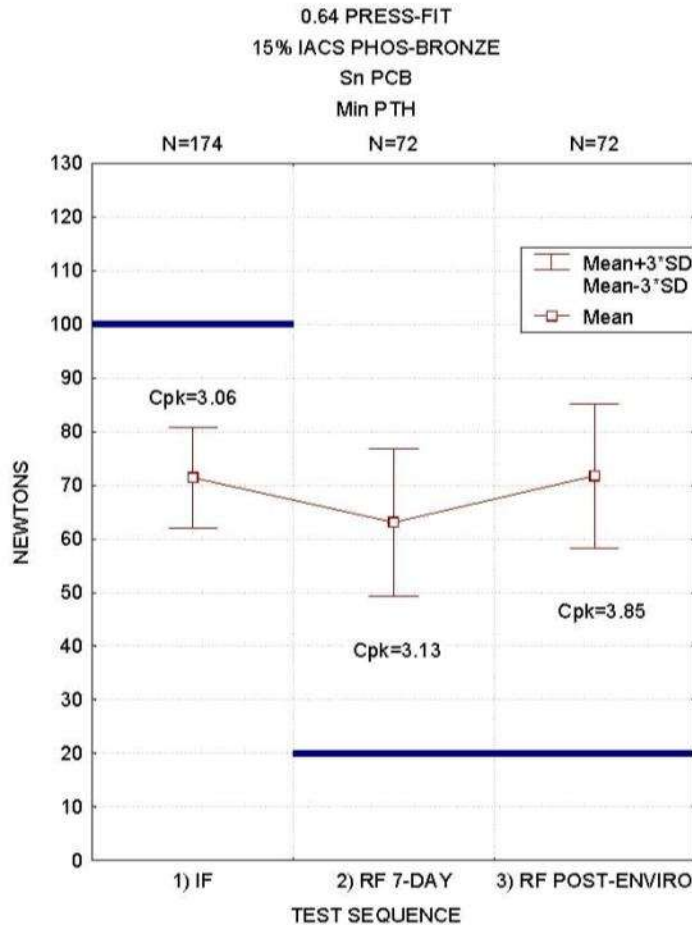
OEM Automotive Temperature classes

Temperature class	Temperature range	
	T _{lo}	T _{up}
1	-40 °C	+105 °C
2	-40 °C	+125 °C
3	-40 °C	+150 °C
4	-40 °C	+175 °C

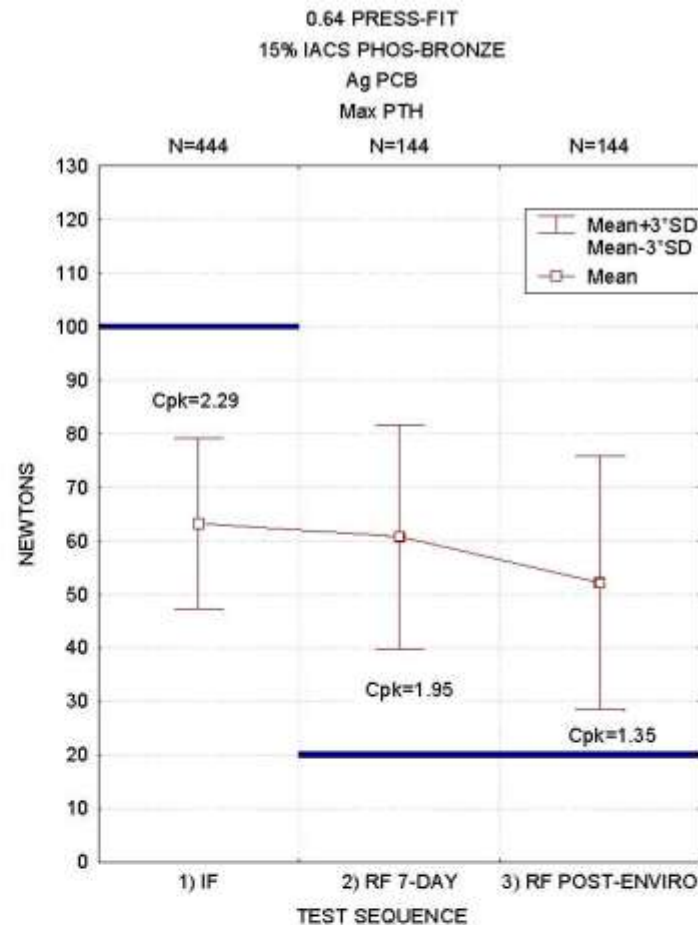
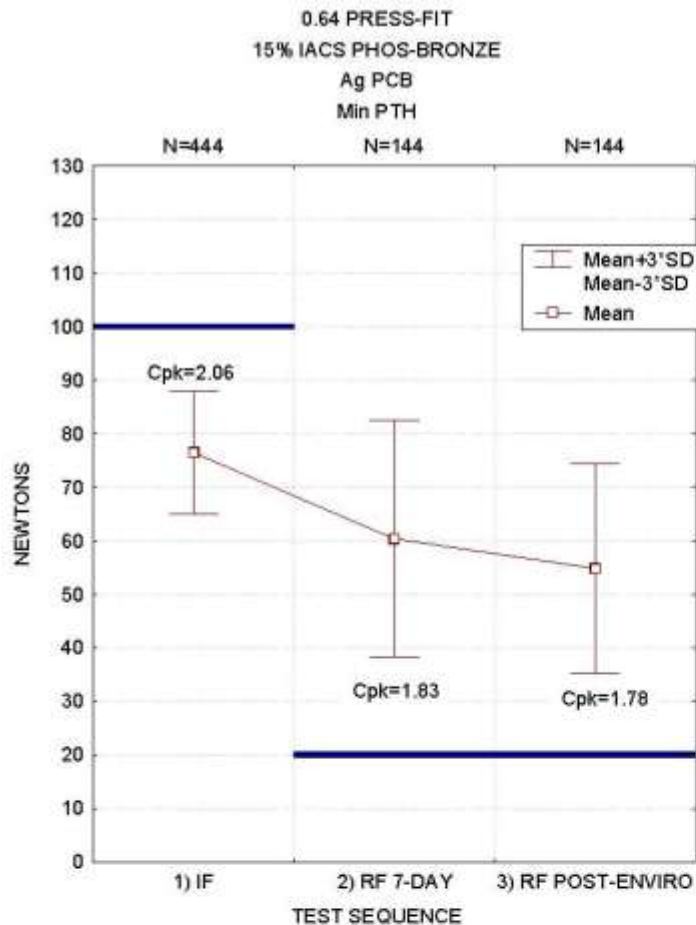
SAE Temperature Classifications

Class	Ambient Temperature Range
1	-40° C to + 85° C
2	-40° C to + 100° C
3	-40° C to + 125° C
4	-40° C to + 150° C
5	-40° C to + 175° C

Summary of Interplex 0.64mm Press-Fit IF/RF Testing –Sn PCB's



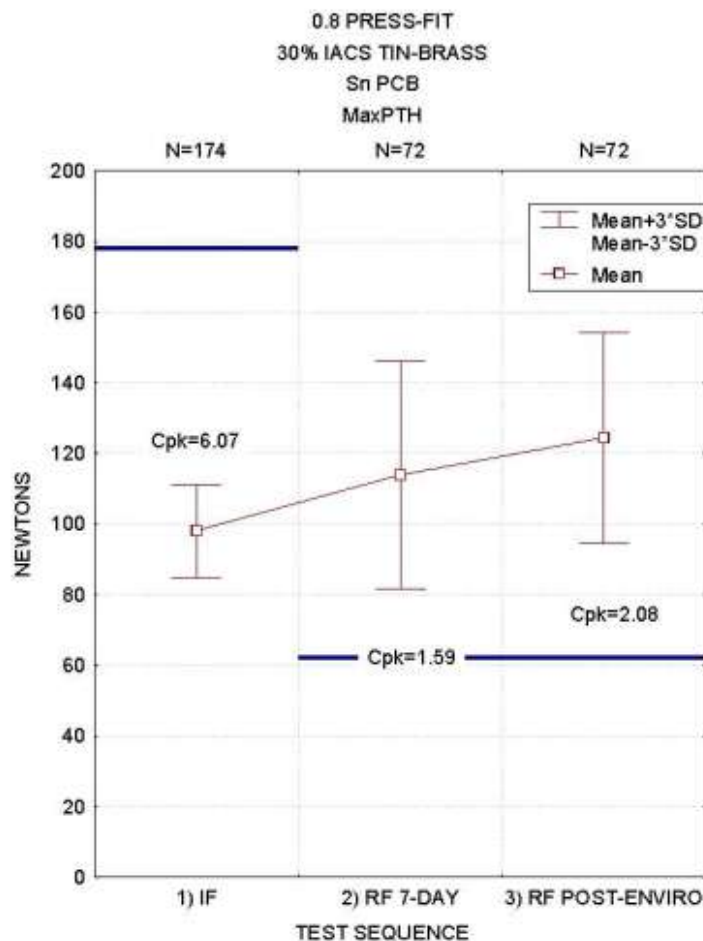
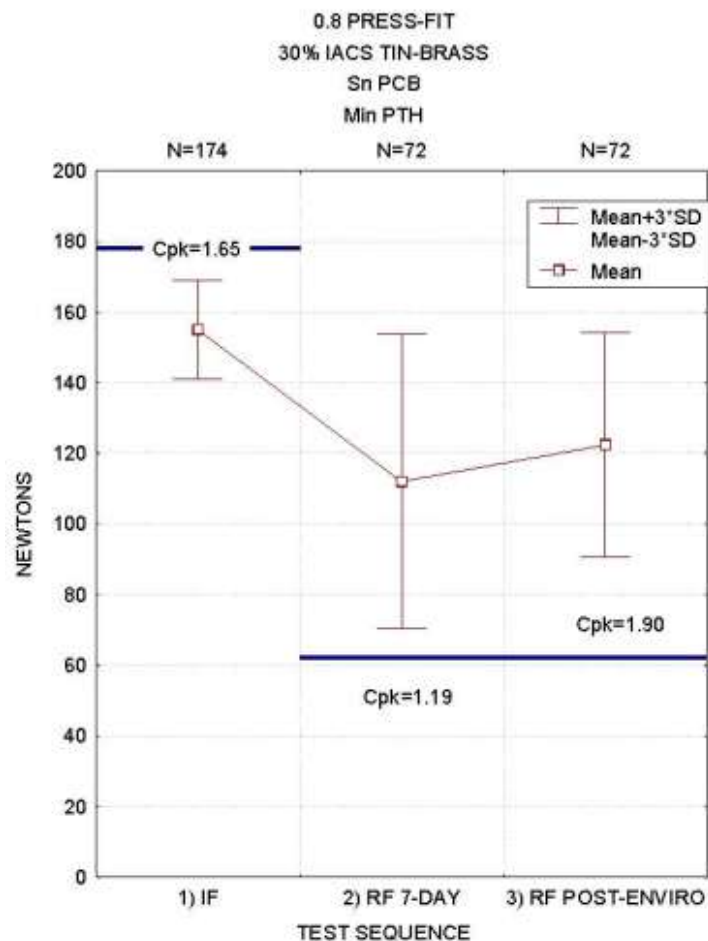
Summary of Interplex 0.64mm Press-Fit IF/RF Testing –Ag PCB's



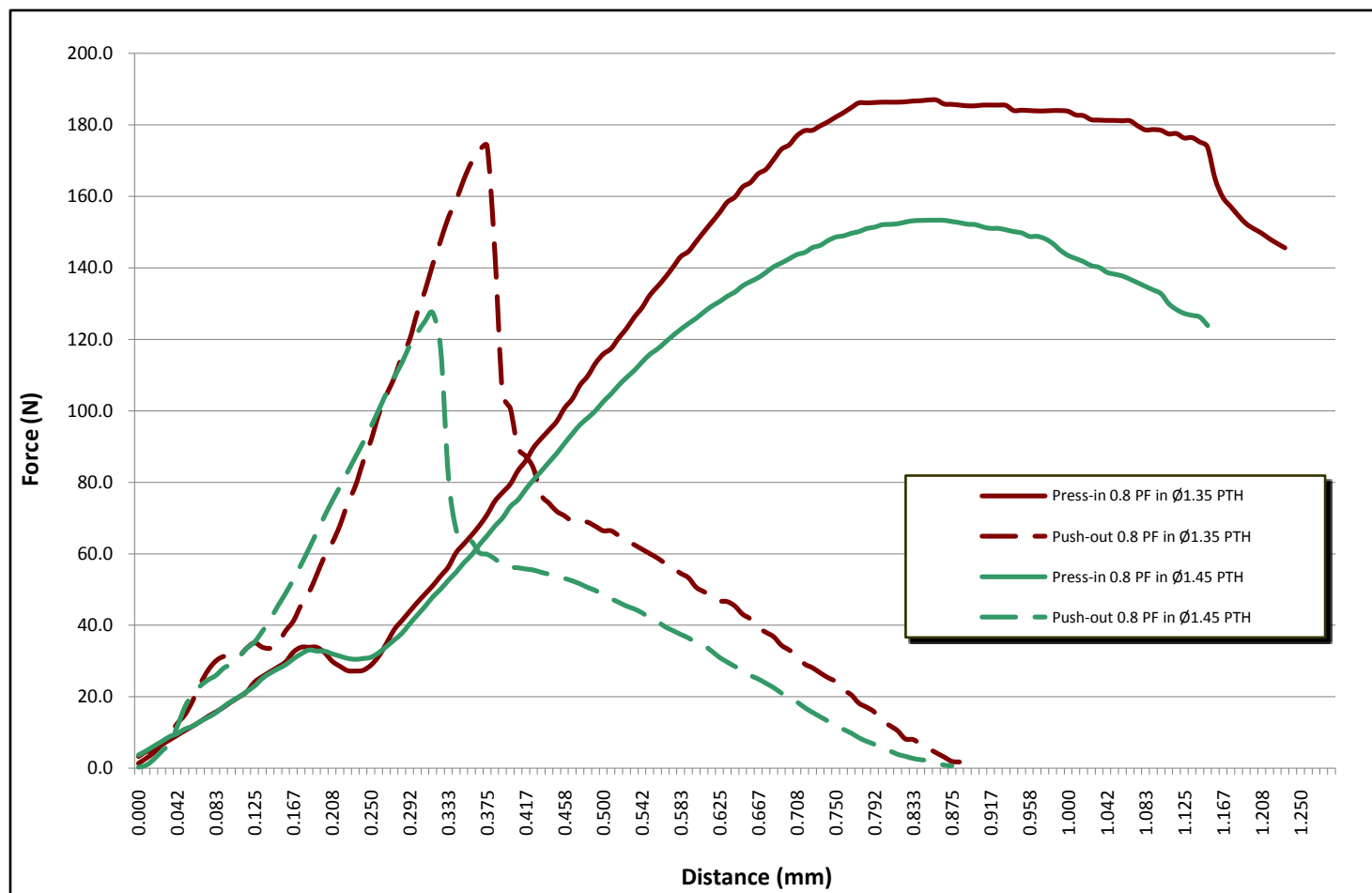
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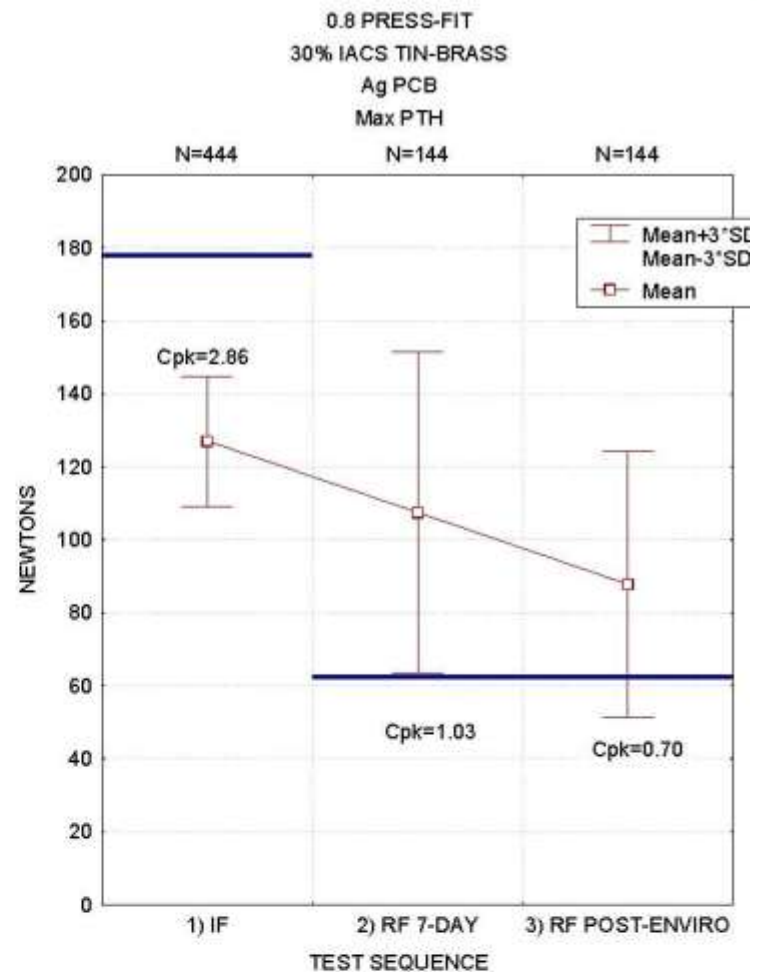
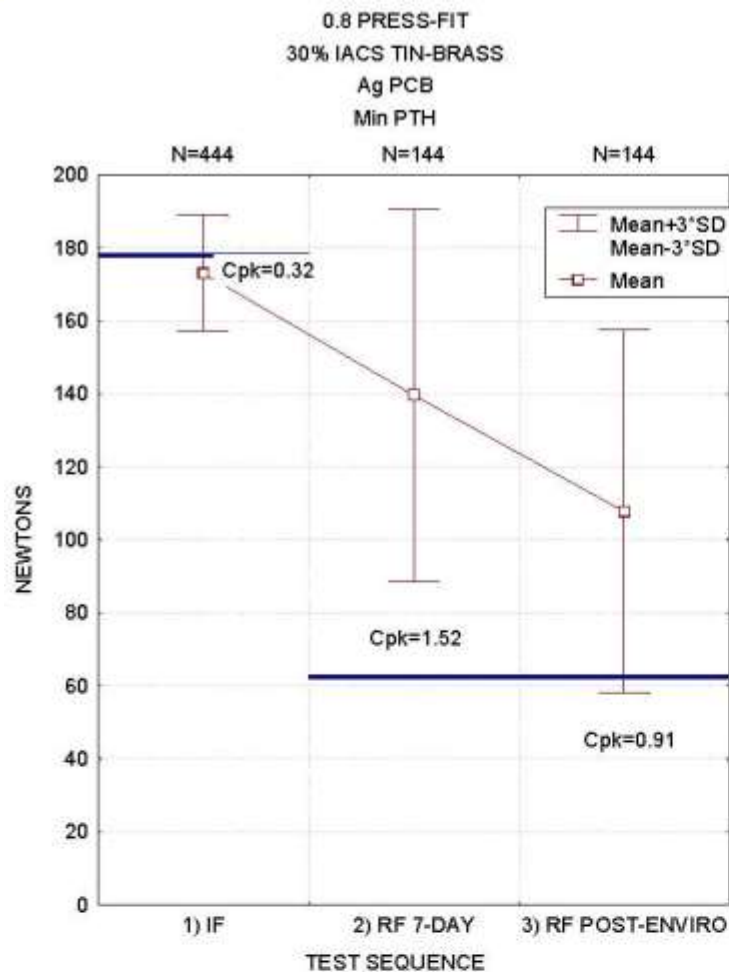
Summary of Interplex 0.80mm Press-Fit IF/RF Testing –Sn PCB's



Summary of Interplex 0.80mm Press-Fit IF/RF Testing –Sn PCB's



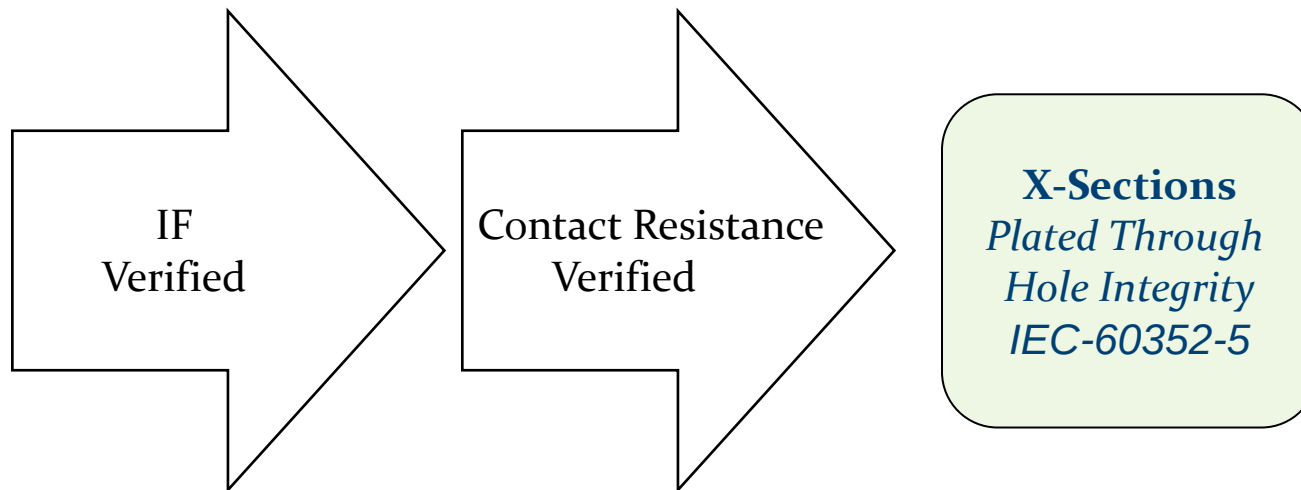
Summary of Interplex 0.80mm Press-Fit IF/RF Testing –Ag PCB's



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Testing Results Plated Through Hole Integrity IEC -60352-5 Requirements



Testing Results Plated Through Hole Integrity

IEC -60352-5 Requirements

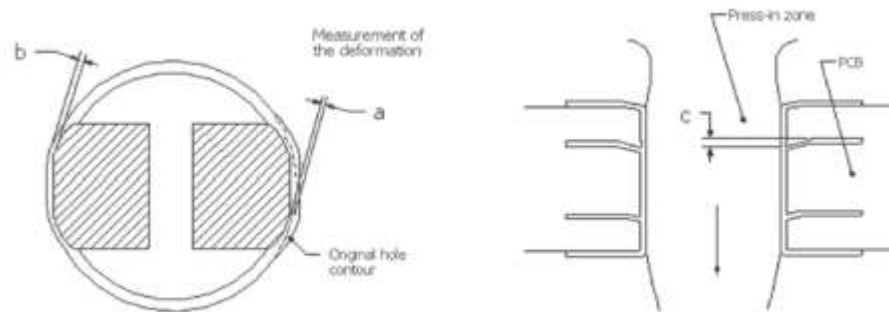
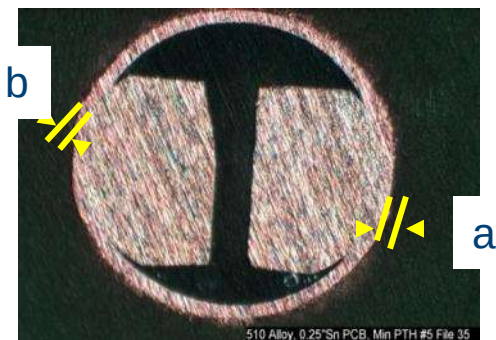
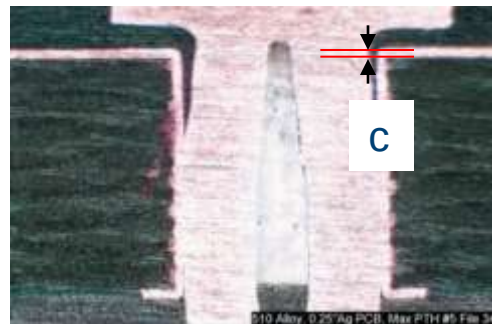


Figure 8: Transverse and Longitudinal Cross-sectioning Measurement Locations

Horizontal



Vertical Single Layer



Vertical Four Layer



b= Plating Thickness

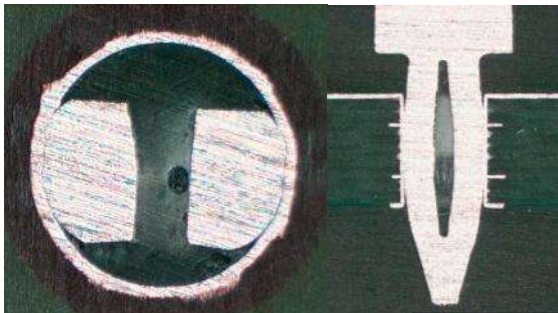
a= Drill Hole Contour Deformation

c= Trace Deformation

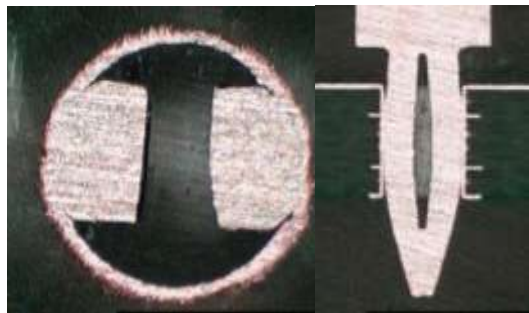
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0.64 mm Plated Through Hole Integrity



Lower Limit Hole



Upper Limit Hole

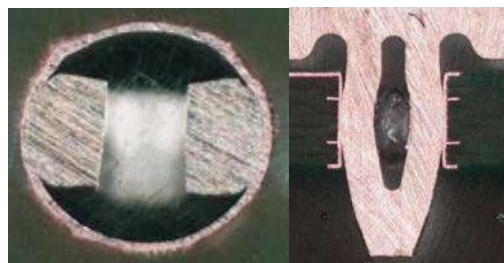
PTH size	Drill Hole Contour Deformation "a" [μm]		Remaining Plating Thickness "b" [μm]		Vertical Trace Deformation "c" [μm]	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Maximum value	19.3	14.7	34.0	30.0	18.8	6.1
Mean value	9.9	7.1	37.6	25.0	9.1	3.0
Minimum value	3.3	1.5	21.5	20.5	1.5	0.0
Requirement	50.8 maximum		8.0 minimum		50.0 maximum	

PTH size	Drill Hole Contour Deformation "a" [μm]		Remaining Plating Thickness "b" [μm]		Vertical Trace Deformation "c" [μm]	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Maximum value	31.8	30.2	58.4	61.1	17.8	12.7
Mean value	22.5	26.8	51.0	44.0	9.7	6.4
Minimum value	14.6	22.9	44.5	27.8	3.8	3.2
Requirement	50.8 maximum		8.0 minimum		50.0 maximum	

0.80 mm Plated Through Hole Integrity



Lower Limit Hole



Upper Limit Hole

PTH Size	Drill Hole Contour Deformation "a" (μm)		Remaining Plating Thickness "b" (μm)		Vertical Trace Deformation "c" (μm)	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Maximum Value	28.6	27.8	45.7	43.5	44.5	26.0
Mean Value	20.3	14.9	33.4	31.9	30.9	17.4
Minimum Value	11.8	7.0	21.5	26.0	13.5	12.0
Requirement	50.8 Maximum		8.0 Minimum		50.0 Maximum	

PTH Size	Drill Hole Contour Deformation "a" (μm)		Remaining Plating Thickness "b" (μm)		Vertical Trace Deformation "c" (μm)	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Maximum Value	26.7	25.4	40.6	37.8	26.0	10.0
Mean Value	22.0	23.3	30.0	30.7	18.5	4.5
Minimum Value	17.1	20.3	20.3	25.9	9.0	2.0
Requirement	50.8 Maximum		8.0 Minimum		50.0 Maximum	

Approvals ...

Standards applicable

IEC, EIA, SAE

Tier 1 Automotive OEM,

OEM Qualifications

Hella, Conti, Bosch, TRW, Volkswagen, GM & Omron etc.



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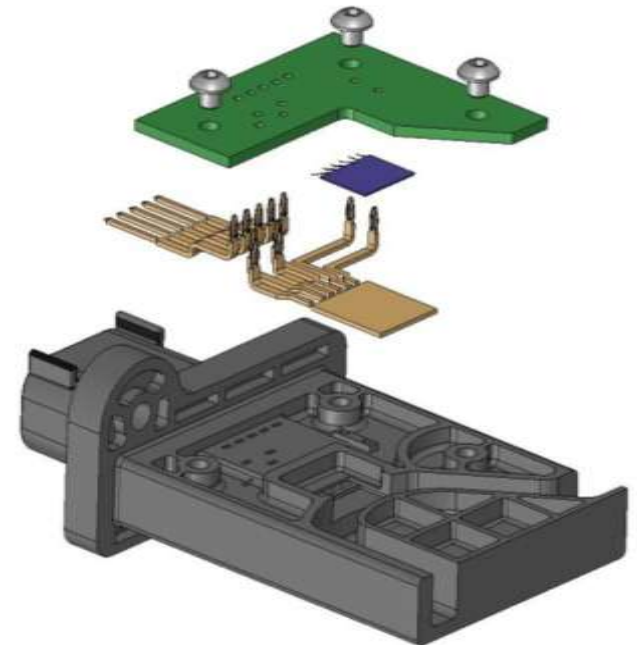
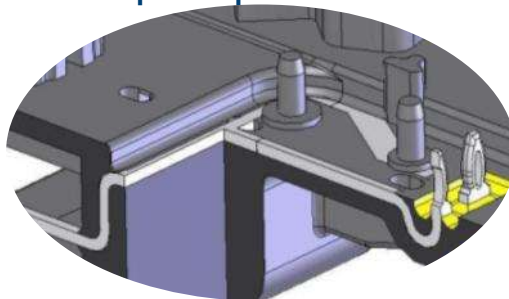
Module development

Design Drivers

- 1.) Operational Temperature & Mounting Location
- 2.) Sealed or unsealed requirements
- 3.) PCB Plating and PCB Thickness
- 4.) Power Requirements and Lead Interface
- 5.) Operational frequency

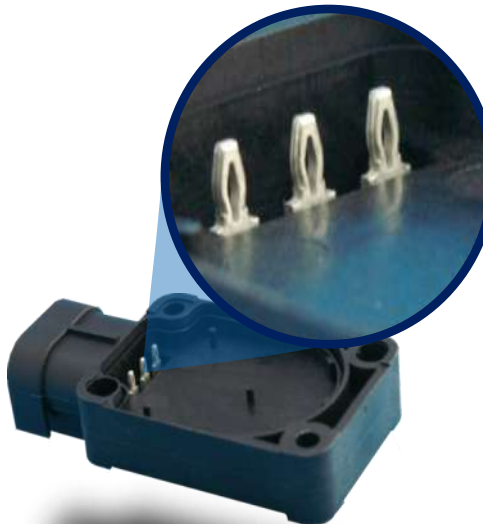
Options & features Effected by Design Drivers

- 1.) Raw Material- 4 core options +
- 2.) Plating Lead Interface- Various interconnect and wire bondable options
- 3.) Press-Fit Gauge Thickness
- 4.) Plastic material- Multiple options
- 5.) Bend Radius



Integrated Connector Package Modules

- Plug & Play philosophy
- Complex Engineering:
 - Stamp
 - Plate
 - Mold



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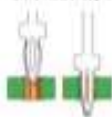
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Customer Specific Application Testing



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Report Summary for Interplex 0.8mm Thick Press-Fit Pins in Bosch supplied PCBs

Interplex PF Pin material: CuNi3Si1Mg, Wieland K55 (C7025) B650 temper

Performance Summary

(Raw data on next page)

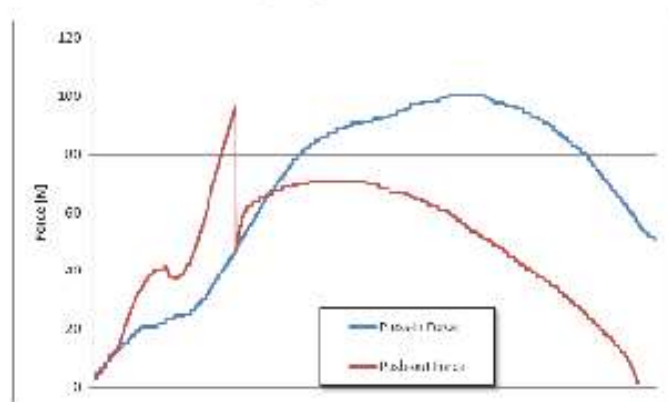
Table 1: Mechanical Force Summary

	Press-in Force [N]	Push-out Force [N]
MAX value	112.7	101.6
AVE value	101.3	84.6
MIN value	89.7	65.1
Sample Size	33 Pins	27 Pins

Table 2: Contact Resistance Summary

	Contact Resistance [mΩ]
MAX value	0.106
AVE value	0.081
MIN value	0.039
Sample Size	33 Pins

Figure 1: Representative Force Curves



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Microsection Data

Figure 2: Microsectioning Procedure and Measurement Locations

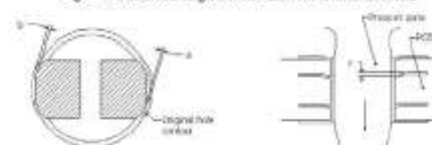


Figure 3: Horizontal and Vertical Microsection Pictures

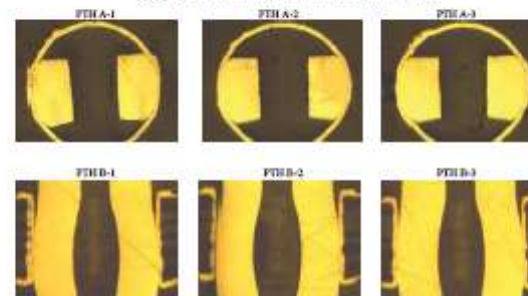


Table 4: Microsection Measurements

PTH #	Drill hole Ø [mm]	Plated Hole Ø [mm]	a	b	c
1	1.658	1.541	35 µm	35 µm	48 µm
2	1.647	1.529	46 µm	43 µm	31 µm
3	1.650	1.534	38 µm	41 µm	25 µm

Microsection Notes:

- * "a" = Radial plated-through hole (PTH) deformation; maximum value recorded per sample
- * "b" = Remaining plating thickness; minimum value recorded per sample
- * "c" = Plated-through hole vertical layer deformation; maximum value recorded per sample



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Automotive Applications ...



Motor & Flapper Controls

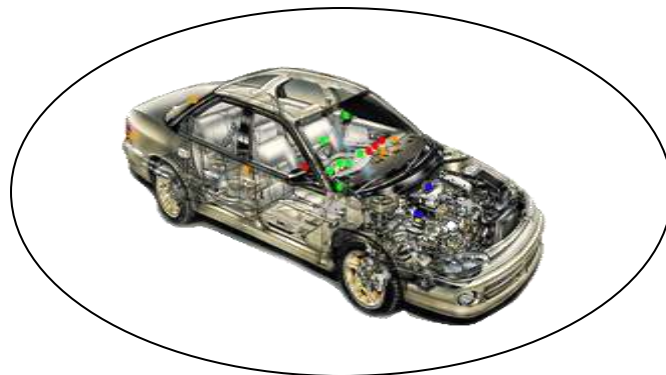


Molded Sensor & Control Modules

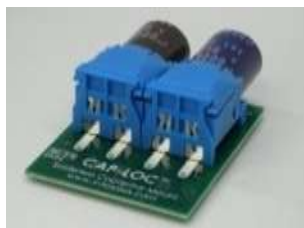
Bus Bar Interconnects & Fuse Receptacles



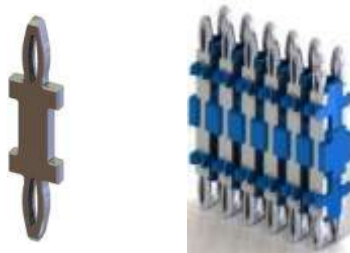
Tire Pressure Monitors



Junction Boxes



Component Holders



Solder Less Circuit Stacking Applications



Engine & Transmission Controllers

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Other Applications...

Telecomms

- Telecom- Backplane

Automotive

- MAP, Pressure & Position Sensors
- Inverters & Power Module

Transport

- IGBT Power modules

Energy

- Solar Interconnects

Future

- DC to DC power Conversions
- Transportation, Energy-Oil & Gas, Wind energy
- IDC to press-fit applications



Direct Insert Press-fit Applications...



Conclusions

- Automotive Electronics is a primary “Harsh Environment” for electronic connectors...
- Motor and Power control equipment will be the next major development area for electronic interconnection issues
- Press-Fit interconnects are an enabler for more reliable and robust connections in Harsh Environments
- Adaption to Integrated Connector Package Modules (ICPM) will contribute to greener, more sustainable electronics



Thank you for your attention



The Authors would like to Acknowledge the help and assistance of :

- Interplex Engineered Products- East Providence RI
- Interplex Soprec, Besancon
- France
- Test Authorities
 - Contech Research, Attleboro, MA
 - SGS Germany GmbH , München
 - Intertek Labs, Livonia, MI

For their assistance and permission to publish this information.



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