



台灣聯合科技股份有限公司

Taiwan Union Technology

## TEST REPORT

**CLIENT:** IPC Validation Services  
3000 Lakeside Drive  
Suite 105N  
Bannockburn, IL 60015 USA  
Attention: Mr. Randy Cherry  
+1-847-597-5606

**TEST ITEMS:** Peel Strength, Volume Resistivity, Surface Resistivity, Moisture Absorption, Dielectric Breakdown, Permittivity @ 1 MHz, Loss Tangent @ 1 MHz, Flexural Strength, Arc Resistance, Thermal Stress, Electric Strength, Flammability, Glass Transition Temperature, Decomposition Temperature, CTE (TMA), Time to Delamination (T260, T288, T300), Dimensional Stability, Solderability, Chemical Resistance, Metal Surfaces Cleanability, Pressure Cooker Test.

**SAMPLE:** Copper-Clad Laminate

**TEST MATERIAL:** TU-933E

**SPECIFICATION:** IPC-4101E WAM1/102

**TEST RESULTS:** The specimens were tested by the indicated test methods within this report.  
The actual detailed test results are enclosed.

**DATE OF REPORT:** 16 August 2022



SUMMARIZED TEST RESULTS:

Test Item	Thin	Thick
Peel Strength	Pass	Pass
Volume Resistivity	Pass	Pass
Surface Resistivity	Pass	Pass
Moisture Absorption	--	Pass
Dielectric Breakdown	--	Pass
Permittivity @ 1MHz	Pass	Pass
Loss Tangent @ 1MHz	Pass	Pass
Flexural Strength	--	Pass
Arc Resistance	Pass	Pass
Surface Resistivity	Pass	Pass
Thermal Stress	Pass	Pass
Electric Strength	Pass	Pass
Flammability	Pass	Pass
Glass Transition Temperature	--	Pass
Decomposition Temperature	--	Pass
Z-Axis CTE	--	Pass
Time to Delamination	--	Pass
Dimensional Stability	Pass	Pass
Solderability	--	Pass
Chemical Resistance	Report Only	Report Only
Metal Surface Cleanability	--	Report Only
Pressure Cooker Test	--	Report Only

## Peel Strength

### Reference:

IPC-TM-650 Method 2.4.8 Peel Strength of Metal Clad Laminates

IPC-TM-650 Method 3.4.8.3 Peel Strength of Metal Clad Laminates at Elevated Temperature

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

### Results:

**Table 1 Peel Strength After Thermal Strength Thin**

Side A Cross-Wise and Length-Wise Average	0.76	
Side B Cross-Wise and Length-Wise Average	0.77	
Requirement	$\geq 0.70$	Pass

**Table 2 Peel Strength After Thermal Strength Thick**

Side A Cross-Wise and Length-Wise Average	0.78	
Side B Cross-Wise and Length-Wise Average	0.76	
Requirement	$\geq 0.70$	Pass

**Table 3 Peel Strength At Elevated Temperature Thin**

Side A Cross-Wise and Length-Wise Average	0.74	
Side B Cross-Wise and Length-Wise Average	0.75	
Requirement	$\geq 0.70$	Pass

**Table 4 Peel Strength At Elevated Temperature Thick**

Side A Cross-Wise and Length-Wise Average	0.77	
Side B Cross-Wise and Length-Wise Average	0.78	
Requirement	$\geq 0.70$	Pass



**Table 5 Peel Strength After Process Solutions Thin**

Side A Cross-Wise and Length-Wise Average	0.76	
Side B Cross-Wise and Length-Wise Average	0.77	
Requirement	$\geq 0.70$	Pass

**Table 6 Peel Strength After Process Solutions Thick**

Side A Cross-Wise and Length-Wise Average	0.77	
Side B Cross-Wise and Length-Wise Average	0.79	
Requirement	$\geq 0.70$	Pass

**Table 7 Peel Strength As Received Low Profile Copper Thin**

Side A Cross-Wise and Length-Wise Average	
Side B Cross-Wise and Length-Wise Average	
Requirement	ABBUS

**Table 8 Peel Strength As Received Low Profile Copper Thick**

Side A Cross-Wise and Length-Wise Average	
Side B Cross-Wise and Length-Wise Average	
Requirement	ABBUS

## Volume & Surface Resistivity

### Reference:

IPC-TM-650 Method 2.5.17.1 Volume and Surface Resistivity of Dielectric Materials  
IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer  
Printed Board

## Results:

**Table 9 Volume and Surface Resistivity Humidity Conditioning Thin**

Volume Resistivity	Average of three specimens	4.32 E+08	
Requirement C-96/35/90		$\geq 1.00 \text{ E}+06$	Pass
Surface Resistivity	Average of three specimens	2.51 E+08	
Requirement C-96/35/90		$\geq 1.00 \text{ E}+05$	Pass

**Table 10 Volume and Surface Resistivity At Elevated Temperature Thin**

Volume Resistivity	Average of three specimens	2.32 E+08	
Requirement 125°C		$\geq 1.00 \text{ E}+06$	Pass
Surface Resistivity	Average of three specimens	4.23 E+08	
Requirement 125°C		$\geq 1.00 \text{ E}+05$	Pass

**Table 11 Volume and Surface Resistivity Humidity Conditioning Thick**

Volume Resistivity	Average of three specimens	2.45 E+09	
Requirement after moisture		1.00 E+06	Pass
Surface Resistivity	Average of three specimens	6.38 E+06	
Requirement after moisture		$\geq 1.00 \text{ E}+05$	Pass

**Table 12 Volume and Surface Resistivity At Elevated Temperature Thick**

Volume Resistivity	Average of three specimens	2.54 E+07	
Requirement 125°C		$\geq 1.00 \text{ E}+06$	Pass



Surface Resistivity	Average of three specimens	4.32 E+09	
Requirement 125°C		$\geq 1.00 \text{ E}+05$	Pass

## Moisture Absorption

### Reference:

IPC-TM-650 Method 2.6.2.1 Water Absorption of Metal Clad Plastic Laminates  
 IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

### Results:

**Table 13 Moisture Absorption Thick**

Moisture Absorption	Average of three specimens	0.14	
Requirement		$\leq 0.5$	Pass

## Dielectric Breakdown

### Reference:

IPC-TM-650 Method 2.5.6 Dielectric Breakdown  
 IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

### Results:

**Table 14 Dielectric Breakdown**

Dielectric Breakdown	Average of four specimens	44+	
Requirement		$\geq 40$	Pass



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## **Permittivity and Loss Tangent @ 1 MHz**



Reference:

IPC-TM-650 Method 2.5.5.9 Permittivity and Loss Tangent, Parallel Plate 1 MHz to 1.5 MHz  
IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

Results:

Table 15 Permittivity and Loss Tangent

Permittivity @ 1 MHz Requirement Thin	Average of three specimens	3.89 $\leq 4.3$	Pass
Loss Tangent @ 1 MHz Requirement Thin	Average of three specimens	0.002 $\leq 0.007$	Pass
Permittivity @ 1 MHz Requirement Thick	Average of three specimens	3.42 $\leq 4.3$	Pass
Loss Tangent @ 1 MHz Requirement Thick	Average of three specimens	0.001 $\leq 0.007$	Pass

## Flexural Strength





**Reference:**

IPC-TM-650 Method 2.4.4 Flexural Strength of Laminates at Ambient Temperature  
IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer  
Printed Board

**Results:**

**Table 16 Flexural Strength**

Flexural Strength Length Direction Requirement	Average of two specimens	365	$\geq 345$	Pass
Flexural Strength Cross Direction Requirement	Average of two specimens	375	$\geq 345$	Pass

## Arc Resistance

**Reference:**

IPC-TM-650 Method 2.5.1 Arc Resistance of Printed Wiring Material  
IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

**Results:**

**Table 17 Arc Resistance**

Arc Resistance Thin Requirement	Average of three specimens	142	$\geq 60$	Pass
Arc Resistance Thick Requirement	Average of three specimens	145	$\geq 60$	Pass



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**Thermal Stress**

**Reference:**

IPC-TM-650 Method 2.4.13.1 Thermal Stress of Laminates

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

**Results:**

**Table 18 Thermal Stress**

Thermal Stress Thin Etched A Side	No obvious blister, delamination or damage	Pass
Thermal Stress Thin Etched B Side	No obvious blister, delamination or damage	Pass
Thermal Stress Thick Etched A Side	No obvious blister, delamination or damage	Pass
Thermal Stress Thick Etched B Side	No obvious blister, delamination or damage	Pass
Thermal Stress Thin Un-Etched A Side	No obvious blister, delamination or damage	Pass
Thermal Stress Thin Un-Etched B Side	No obvious blister, delamination or damage	Pass
Thermal Stress Thick Un-Etched A Side	No obvious blister, delamination or damage	Pass
Thermal Stress Thick Un-Etched B Side	No obvious blister, delamination or damage	Pass

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## Electric Strength

**Reference:**

IPC-TM-650 Method 2.5.6.2 Electric Strength

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

**Results:**

**Table 19 Electric Strength**

Electric Strength Thin Requirement	Average of three specimens	77	
		$\geq 30$	Pass

## Flammability Vertical Burning

### Reference:

UL94 Section 8 50W (20mm) Vertical Burning Test; V-0, V-1, V-2

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

### Results:

#### Table 20 Vertical Burning Test Thin

The specimens were tested by the methods given above.

The flammability Classification Condition A of specimens is V-0

The flammability Classification Condition A of specimens is V-0

The specimens pass.

#### Table 21 Vertical Burning Test Thick

The specimens were tested by the methods given above.

The flammability Classification Condition A of specimens is V-0

The flammability Classification Condition B of specimens is V-0

The specimens pass.

## Glass Transition Temperature

### Reference:

IPC-TM-650 Method 2.4.25 Glass Transition Temperature and Cure Factor by DSC

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Boards

### Results:

#### Table 22 Glass Transition Temperature



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Glass Transition Temperature

195°C



## Decomposition Temperature

### Reference:

IPC-TM-650 Method 2.4.24.6 Decomposition Temperature of Laminate Material Using TGA  
IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

### Results:

**Table 23 Decomposition Temperature**

Glass Transition Temperature 5% Weight Loss	395°C	
Requirement	≥ 340	Pass

## Z-Axis CTE (TMA)

### Reference:

IPC-TM-650 Method 2.4.24.6 Decomposition Temperature of Laminate Material Using TGA  
IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

### Results:

**Table 24 Z-Axis CTE (TMA)**

Z-Axis CTE Alpha 1	Average of two specimens	42	
		≤ 60	Pass



Z-Axis CTE Alpha 2	Average of two specimens	235	
		≤ 300	Pass
Z-Axis CTE 50-260	Average of two specimens	2.6	
		≤ 3.0	Pass

## Time to Delamination

### Reference:

IPC-TM-650 Method 2.4.24.1 Time to Delamination (TMA Method)

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

### Results:

**Table 25 Time to Delamination (TMA)**

Delamination T260	Average of two specimens	> 60	
	Requirement	≥ 30	Pass
Delamination T288	Average of two specimens	> 45	
	Requirement	≥ 15	Pass
Delamination T300	Average of two specimens	> 4	
	Requirement	≥ 2	Pass

## Dimensional Stability

### Reference:

IPC-TM-650 Method 2.4.39 Dimensional Stability, Glass Reinforced Thin Laminates



Results:

Table 26 Dimensional Stability Thin

Dimensional Stability Bake	Average of three specimens		
	Machine direction	-0.06	
	Cross direction	-0.07	
	Requirement	-0.3 to +0.3	Pass
Dimensional Stability Stress	Average of three specimens		
	Machine direction	-0.05	
	Cross direction	-0.08	
	Requirement	-0.3 to +0.3	Pass

Table 27 Dimensional Stability Thick

Dimensional Stability Bake	Average of three specimens		
	Machine direction	-0.05	
	Cross direction	-0.04	
	Requirement	-0.3 to +0.3	Pass
Dimensional Stability Stress	Average of three specimens		
	Machine direction	-0.06	
	Cross direction	-0.03	
	Requirement	-0.3 to +0.3	Pass

Solderability (Edge Dip Test)

Reference:

IPC-J-STD-003C; Method 4.2.1 Edge Dip Test

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board



**Results:**

**Table 28 Solderability (TMA)**

Solderability Thin	Sample surface exhibited good wetting	Pass
Solderability Thick	Sample surface exhibited good wetting	Pass

## Chemical Resistance

**Reference:**

IPC-TM-650 Method 2.3.4.2 Chemical Resistance of Laminates, Prepreg and Coated Foil Products by Solvent Exposure.

IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

**Results:**

**Table 29 Chemical Resistance**

Chemical Resistance Thin	Three specimens		
Requirement	Appearance after bake	No change	Pass
Requirement	Appearance after solvent	No change	Pass
Chemical Resistance Thick	Three specimens		
Requirement	Appearance after bake	No change	Pass
Requirement	Appearance after solvent	No change	Pass

## Metal Surface Cleanability

**Reference:**





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IPC-TM-650 Method 2.3.1.1 Chemical Cleaning of Metal-Clad Laminate



**Results:**

**Table 30 Metal Surface Cleanability**

Metal Surface Cleanability	Three specimens	
Requirement	The metal cladding on the test specimen shall be cleaned to a uniform matte finish. Deionized or distilled water poured on the surface does not bead or form puddles.	Pass

## Pressure Cooker Test

**Reference:**

IPC-TM-650 Method 2.6.16 Pressure Vessel Method for Glass Epoxy Laminate Integrity  
IPC-4101E WAM1/102 Specification for Base Materials for Rigid and Multilayer Printed Board

**Results:**

**Table 31 Pressure Cooker Test**

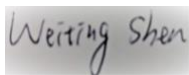
Pressure Cooker Test	Five specimens	
Requirement	The samples shall have no measles, blisters or surface erosion	Pass

## CERTIFICATE OF CONFORMANCE

The TAWIAN UNION TECHNOLOGY CORPORATION (TUC) certifies that the test equipment used complies with the requirements of correlation criterion and that data contained in this report is accurate within the tolerance limitation of the equipment.

The report is invalid without the signature of the reviewer and the approver.

Reviewed by:



QA Engineer

16 August 2022

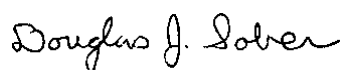
Approved by:



Money Wang

QA Manager

16 August 2022



For IPC

16 August 2022