IPC-4103A Amendment 1

2014 - January

Specification for Base Materials for High Speed/ High Frequency Applications

A standard developed by IPC

Association Connecting Electronics Industries

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- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

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- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

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Specification for Base Materials for High Speed / High Frequency Applications

- Replace the third paragraph of section **1.2 Type Designation** with the following:

Table 1-2 provides an example for enhanced laminate part numbers where IPC-4103 is referenced. In addition to the conventional Table 1-2, the following designators could be used to define an enhanced material part number such as: 4103AL001C11500C1/C1AAX1A1A.

- Replace **Table 1-2 Enhanced Laminate Example** with the following:

Table 1-2 Enhanced Laminate Example

X	1	A	1	A
Test Frequency (see 1.2.8)	Dielectric Loss (see 1.2.9)	Resin (see 1.2.10)	Filler (see 1.2.11)	Reinforcement (see 1.2.12)

- Replace the fourth paragraph of section **1.2 Type Designation** with the following:

Table 1-3 provides an example for bonding layer part numbers where IPC-4103 is referenced as follows: 4103AB520CE1080BRCSCVC1.

- Replace **Table 1-3 Bonding Layer Example** with the following:

Table 1-3 Bonding Layer Example

4103	A	B	520	C
Specification Number	Specification Revision	Material Designator (see 1.2.1)	Specification Sheet (see 1.2.1)	Dielectric Permittivity Range (see 1.2.2)
E	**1080**	**B**	**RC**	**SC**
Reinforcement Type (see 1.2.13)	Reinforcement Style (see 1.2.13)	Resin System (see 1.2.10)	Resin Content Test Method (see 1.2.14)	Flow Parameter (see 1.2.14)
VC	**1**			
Optional Test (see 1.2.14)	Filler (see 1.2.11)			

- Replace the first paragraph of section **1.2.1.2 New Format Specification Sheets** with the following:

1.2.1.2 New Format Specification Sheets This applies to specification sheets that are in the 200 Series and 500 series. On these specification sheets, the Dk, Df, and descriptions are mandatory requirements. Based on other criteria (e.g. CTE, Td, moisture absorption, thermal conductivity), the number of potential specification sheets in the 200 Series and 500 Series could equal 150. Desiring to minimize the number of specification sheets while simplifying the specification sheet system, a "loose/tight" specification sheet concept was created for this revision of IPC-4103; one for which laminate suppliers could use to certify their materials, while OEMs could use to find materials. "Loose/tight" specification sheets provide both "tight" mandatory requirements (Dk, Df, description) as well as "loose" requirements (e.g. thermal conductivity, moisture absorption) that can be certified to or called out on the fabrication drawings. Low loss and higher loss tangent materials have been merged into the same grouping. Hence, fewer specification sheets are required. The same classification logic works for bonding layers in the 500 Series.

- Replace section **1.2.5 Thickness Tolerance, Laminate** with the following:

1.2.5 Thickness Tolerance, Laminate The class of thickness tolerance for laminate base material is identified by either A, B, C, D, or X as agreed upon between user and supplier (AABUS) (see 3.8.4.2 and Table 3-5).

- Replace section **1.2.7.1 Metallic Cladding Designators** with the following:

1.2.7.1 Metallic Cladding Designators The types of metallic cladding and the designators representing them include:

A	Copper, wrought, rolled (IPC-4562, Grade 5)
B	Copper, rolled (treated)
C	Copper, electrodeposited (IPC-4562, Grade 1)
D	Copper, electrodeposited, double treated (IPC-4562, Grade 1)
G	Copper, electrodeposited, high ductility (IPC-4562, Grade 2)
H	Copper, electrodeposited, high temperature elongation (IPC-4562, Grade 3)
K	Copper, wrought, light cold rolled (IPC-4562, Grade 6)
L	Copper, wrought, annealed (IPC-4562, Grade 7)
M	Copper, wrought, rolled, low temperature annealable (IPC-4562, Grade 8)
N	Nickel
O	Unclad
P	Copper, electrodeposited, high temperature elongation, double treated (IPC-4562, Grade 3)
R	Copper, reverse treated electrodeposited (IPC-4562, Grade 1)
S	Copper, reverse treated electrodeposited, high temperature elongation (IPC-4562, Grade 3)
T	Copper, copper foil parameters as dictated by contract or purchase order
U	Aluminum
X	As agreed between user and supplier (AABUS)
Y	Copper Invar Copper
Z	Copper, electrodeposited, high temperature elongation, double-treated (IPC-4562, Grade 3) for buried capacitance applications

Note: Except for types D, N, O, P, U and Z, all foils have integral metal/metal oxide treatments for adhesion on one side, and that side is placed against the substrate. Type T may or may not have treatments.

- Replace section **3.8.3.1.6 Surface and Subsurface Imperfections** with the following:

3.8.3.1.6 Surface and Subsurface Imperfections The etched panels **shall** be inspected to verify that no subsurface imperfections in excess of those shown below are present. The panels **shall** be inspected using an optical apparatus or aid that provides a minimum magnification of 4X. Referee magnification **shall** be accomplished at 10X. Lighting conditions of inspection **shall** be appropriate to the type, grade and thickness being inspected or AABUS.

Surface and subsurface imperfections (such as weave texture, resin saturation, scorching, voids, and foreign inclusions) **shall** be acceptable provided the imperfections meet the following:

- The reinforcement fiber is not cut or exposed.
- No more than 1.0% of the board area on each side **shall** be affected.
- White spots are allowable on woven and non-woven glass (PTFE).
- The imperfections do not propagate as a result of thermal stress.
- The foreign inclusions are translucent.
- Voids are < 0.075 mm [0.0029 in] in the longest dimension and do not occur in void clusters any more than two spots per 300 mm x 300 mm [11.81 in x 11.81 in] inspected.

Surface and subsurface nonconductive stains, logos, and discolorations in the dielectric **shall** be acceptable provided the material is not functionally degraded by the discoloration.

- Replace section **3.8.3.2.1 Inclusions** with the following:

3.8.3.2.1 Inclusions Metallic inclusions are not acceptable. Opaque foreign matter other than fibers **shall not** exceed 0.50 mm [0.019 in]. Opaque foreign inclusions <0.13 mm [0.005 in] **shall not** be counted. Opaque foreign inclusions between 0.50 mm [0.019 in] and 0.13 mm [0.005 in] inclusive **shall** average no more than two spots per 300 mm x 300 mm [11.81 in x 11.81 in] inspected.

- Replace section **3.11.2.3 Electric Strength** with the following:

3.11.2.3 Electric Strength When specimens are tested in accordance with Table 3-4, the minimum electric strength **shall** be AABUS or as indicated in the applicable legacy specification sheet.

- Replace **IPC-4103/01** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/01
Reinforcement : Woven E-Glass
Resin System : PTFE
Filler : None
Permittivity Range : 2.45 – 2.65
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 2.45, B – 2.50, C – 2.55, D – 2.60, E – 2.65, X – AABUS*
ID Reference : MIL-13949/8, Type GT
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^6 Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^6 Hz, maximum	0.005	0.005	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	82 [11,900] 69 [10,000]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum (Laminate & bonding layer as laminated)	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability (Laminate & bonding layer as laminated) A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier.

- Replace **IPC-4103/02** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/02
Reinforcement : Woven E-Glass
Resin System : PTFE
Filler : None
Permittivity Range : 2.40 – 2.60
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 2.40, B – 2.45, C – 2.50, D – 2.55, E – 2.60, X – AABUS*
ID Reference : MIL-13949/9, Type GX
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.0025	0.0025	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	82 [11,900] 69 [10,000]	N/mm^2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier.

- Replace **IPC-4103/03** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/03
Reinforcement : Non-Woven E-Glass
Resin System : PTFE
Filler : None
Permittivity Range : 2.15 – 2.35
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 2.15, B – 2.20, C – 2.25, D – 2.30, E – 2.33, F – 2.35, X – AABUS*
ID Reference : MIL-13949/6, Type GP
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.30	0.30	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10^6 Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^6 Hz, maximum	0.0010	0.0010	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	55 [7980] 41 [5950]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 S at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier.

- Replace **IPC-4103/04** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/04
Reinforcement : Non-Woven E-Glass
Resin System : PTFE
Filler : None
Permittivity Range : 2.15 – 2.35
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 2.15, B – 2.20, C – 2.25, D – 2.30, E – 2.33, F – 2.35, X – AABUS*
ID Reference : MIL-13949/7, Type GR
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.10	0.10	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.0015	0.0015	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	24 [3480] 24 [3480]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier.

- Replace **IPC-4103/05** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/05
Reinforcement : Woven E-Glass
Resin System : PTFE
Filler : None
Permittivity Range : 2.15 – 2.35
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 2.15, B – 2.17, C – 2.20, D – 2.30, E – 2.33, F – 2.35, X – AABUS*
ID Reference : MIL-13949/14, Type GY
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.0015	0.0015	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	41 [5950] 35 [5080]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier.

- Replace **IPC-4103/06** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/06
Reinforcement : With or Without Woven or Non-Woven E-Glass
Resin System : PTFE
Filler : Ceramic
Permittivity Range : 3.00 maximum
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 2.80, B – 2.85, C – 2.90, D – 2.92, E – 2.93, F – 2.94, X – AABUS*
ID Reference : N/A
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.13	0.13	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.003	0.003	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	5.5 [798] 5.5 [798]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	25 35	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier.

- Replace **IPC-4103/07** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/07
Reinforcement : With or Without Woven or Non-Woven E-Glass
Resin System : PTFE
Filler : Ceramic
Permittivity Range : 5.0 – 7.0
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 6.00, B – 6.15, X – AABUS*
ID Reference : N/A
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^3 – 10^3	– 10^3 10^3	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^3 – 10^3	– 10^3 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.35	0.35	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	
7. Loss Tangent at 10^{10} Hz, maximum	0.0030	0.0030	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	28 [4060] 21 [3050]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/08** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/08
Reinforcement : With or Without Woven or Non-Woven E-Glass
Resin System : PTFE
Filler : Ceramic
Permittivity Range : 7.5 – 11.0
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 9.8, B – 10.0, C – 10.2, D – 10.5, E – 10.8, X – AABUS*
ID Reference : N/A
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/150	10^3 – 10^3	– 10^3 10^3	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^3 – 10^3	– 10^3 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.35	0.35	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.0035	0.0035	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	28 [4060] 21 [3050]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/09** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/09
Reinforcement : Woven E-Glass
Resin System : PTFE
Filler : With or Without Ceramic
Permittivity Range : 2.70 – 3.60
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 2.75, B – 2.95, C – 3.00, D – 3.20, E – 3.50, X – AABUS*
ID Reference : N/A
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.20	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum A. Permittivity ≥ 3.0 B. Permittivity < 3.0	0.005 0.003	0.005 0.003	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	82 [11,900] 69 [10,000]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	AABUS*	N/A	N/A	N/A
2. Reinforcement	IPC-EG-140A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Minimum Bonding Temperature	AABUS*	°C	AABUS*	N/A
5. Maximum Process Temperature	AABUS*	°C	AABUS*	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/10** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/10
Reinforcement : Woven E-Glass
Resin System : Hydrocarbon
Filler : Ceramic
Permittivity Range : 3.25 – 3.45
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 3.25, B – 3.38, X – AABUS*
ID Reference : N/A
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS 0.52 [2.97] 0.52 [2.97] 0.52 [2.97] AABUS	AABUS 0.52 [2.97] 0.52 [2.97] 0.52 [2.97] AABUS	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.25	0.25	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	34	34	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.004	0.004	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	310 [44,970] 228 [33,070]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	N/A N/A	N/A N/A	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/11** with the following:

SPECIFICATION SHEET

Specification Sheet #	:	**IPC-4103/11**
Reinforcement	:	**Woven E-Glass**
Resin System	:	**Hydrocarbon**
Filler	:	**Ceramic**
Permittivity Range	:	**3.40 – 3.60**
Permittivity Test Frequency	:	**10^6 or 10^{10} Hz**
Nominal Permittivity	:	**A – 3.48, B – 3.58, X – ABBUS***
ID Reference	:	**N/A**
Glass Transition Range	:	**N/A**

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS 0.52 [2.97] 0.52 [2.97] 0.52 [2.97] AABUS	AABUS 0.52 [2.97] 0.52 [2.97] 0.52 [2.97] AABUS	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^5 – 10^4	– 10^5 10^4	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^3 – 10^2	– 10^3 10^2	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.25	0.25	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	30	30	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.006	0.006	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	310 [44,970] 228 [33,070]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/12** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/12
Reinforcement : Woven E-Glass Face Sheets, Non-Woven E-Glass Core
Resin System : Polyester
Filler : Kaolin
Permittivity Range : 3.0 – 4.5
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 3.05, B – 3.20, X – AABUS*
ID Reference : CRM-5
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS 0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	AABUS 0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.50	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.006	0.006	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	151 [21,900] 137 [19,870]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/13** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/13
Reinforcement : Woven E-Glass Face Sheets, Non-Woven E-Glass Core
Resin System : Polyester
Filler : Kaolin
Permittivity Range : 3.00 – 3.50
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 3.20, B – 3.25, C – 3.40, X – AABUS*
ID Reference : CRM-5
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS 0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	AABUS 0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^6 – 10^5	– 10^6 10^5	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^4 – 10^3	– 10^4 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.50	0.20	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	As Specified Above	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.015	0.015	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	151 [21,900] 137 [19,870]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/14** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/14
Reinforcement : Woven E-Glass
Resin System : Polyester
Filler : None
Permittivity Range : 3.0 – 4.0
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 3.05, B – 3.29, X – AABUS*
ID Reference : N/A
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	 AABUS* 0.61 [3.48] 0.61 [3.48] 0.61 [3.48] AABUS*	 – – –	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^6 – 10^5	– – –	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^5 – 10^3	– – –	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.30	–	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	–	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	–	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.008	–	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	 – –	 – –	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	 Pass Visual Pass Visual	 – –	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	20 [508]	–	V/mm [V/mil]	2.5.6.2	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	 5 10	 – –	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	 – –	 – –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/15** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/15
Reinforcement : None
Resin System : Thermoplastic
Filler : None
Permittivity Range : 1.98 – 2.35
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 1.98, B – 2.28, C – 2.32, D – 2.35, X – AABUS*
ID Reference : N/A
Glass Transition Range : A – 121°C, B – 168°C, C – 260°C

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	– – – –	– – – – –	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^{11} – –	– – –	MΩ–cm	ASTM D-257	
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^9 – –	– – –	MΩ	ASTM D-257	
4. Moisture Absorption, maximum	0.05	–	%	ASTM-D-570	3.12.1.1
5. Dielectric Breakdown, minimum	–	–	kV	2.5.6	3.11.1.6
6. Permittivity at 10^6 Hz, maximum	As Specified Above	–	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^6 Hz, maximum	0.003	–	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	– –	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	– –	– –	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	100 [2450]	–	V/mm [V/mil]	ASTM D-149	3.11.1.6 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	– –	– –	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Minimum Bonding Temperature	As specified above	°C	AABUS*	N/A
5. Maximum Process Temperature	AABUS*	°C	AABUS*	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/16** with the following:

SPECIFICATION SHEET

Specification Sheet # : IPC-4103/16
Reinforcement : Woven or Non-Woven E-Glass
Resin System : PTFE
Filler : Ceramic
Permittivity Range : 3.00 – 4.90
Permittivity Test Frequency : 10^6 or 10^{10} Hz
Nominal Permittivity : A – 3.20, B – 3.50, C – 4.50, X – AABUS*
ID Reference : N/A
Glass Transition Range : N/A

LAMINATE REQUIREMENTS

Laminate Requirement	Specification < 0.76 mm [< 0.030 in]	Specification ≥ 0.76 mm [≥ 0.030 in]	Units	Test Method	Ref. Para.
1. Peel Strength, minimum A. Low profile copper foil and very low profile copper foil – all copper weights greater than 1/2 oz. B. Standard profile copper foil 1. After Thermal Stress 2. At 150 °C [302 °F] 3. After Process Solutions C. All other foil – composite	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	AABUS* 0.70 [4.00] 0.70 [4.00] 0.70 [4.00] AABUS*	N/mm [lb/inch]	2.4.8 2.4.8.2 2.4.8.3	3.9.1.1 3.9.1.1.1 3.9.1.1.2 3.9.1.1.3
2. Volume Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^3 – 10^3	10_3 – 10^3	MΩ–cm	2.5.17.1	3.11.1.3
3. Surface Resistivity, minimum A. C-96/35/90 B. After moisture resistance C. At elevated temperature E-24/125	10^3 – 10^3	10_3 – 10^3	MΩ	2.5.17.1	3.11.1.4
4. Moisture Absorption, maximum	0.35	0.35	%	2.6.2.1	3.12.1.1
5. Dielectric Breakdown, minimum	20	20	kV	2.5.6	3.11.1.6
6. Permittivity at 10^{10} Hz, maximum	As Specified Above	–	–	2.5.5.3 2.5.5.5 2.5.5.6	3.11.1.1 3.11.2.1
7. Loss Tangent at 10^{10} Hz, maximum	0.04	0.04	–	2.5.5.3 2.5.5.5	3.11.1.2 3.11.2.2
8. Flexural Strength, minimum A. Length direction B. Cross direction	– –	28 [4060] 21 [3050]	N/mm_2 [$lb/inch^2$]	2.4.4	3.9.1.3
9. Thermal Stress 10 s at 288 °C [550 °F], minimum A. Unetched B. Etched	Pass Visual Pass Visual	Pass Visual Pass Visual	s	2.4.13.1	3.10.1.2
10. Electric Strength, minimum	–	–	V/mm [V/mil]	2.5.6.2	3.11.1.7 3.11.2.3
11. Flammability A. Average burn time, maximum B. Individual burn time, maximum	5 10	5 10	s	2.3.9 2.3.10	3.10.2.1 3.10.1.1
12. CTE, average maximum X,Y Axes Z Axis	– –	– –	ppm/°C	2.4.41 2.4.41.1	3.10.1.8

BONDING LAYER REQUIREMENTS

Bonding Layer Requirement	Specification	Units	Test Method	Ref. Para.
1. Shelf Life, minimum (Condition 1/Condition 2)	N/A	N/A	N/A	N/A
2. Reinforcement	N/A			
3. Volatile content maximum	N/A	N/A	N/A	N/A
4. Bonding Layer Parameters	N/A	N/A	N/A	N/A

*AABUS = As agreed between user and supplier

- Replace **IPC-4103/500** with the following:

Specification Sheet #	:	**IPC-4103/500**
Nominal Dielectric Permittivity Range (Dk)	:	**≤ 2.20**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0015 2) ≥ 0.0015 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/510** with the following:

Specification Sheet #	:	**IPC-4103/510**
Nominal Dielectric Permittivity Range (Dk)	:	**2.21 to 2.33**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0020 2) ≥ 0.0020 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/520** with the following:

Specification Sheet #	:	**IPC-4103/520**
Nominal Dielectric Permittivity Range (Dk)	:	**2.34 to 2.65**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance		**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/530** with the following:

Specification Sheet #	:	**IPC-4103/530**
Nominal Dielectric Permittivity Range (Dk)	:	**2.66 to 3.05**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/540** with the following:

Specification Sheet #	:	**IPC-4103/540**
Nominal Dielectric Permittivity Range (Dk)	:	**3.06 to 3.58**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/550** with the following:

Specification Sheet #	:	**IPC-4103/550**
Nominal Dielectric Permittivity Range (Dk)	:	**3.59 to 4.50**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/560** with the following:

Specification Sheet #	:	**IPC-4103/560**
Nominal Dielectric Permittivity Range (Dk)	:	**4.51 to 5.99**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/570** with the following:

Specification Sheet #	:	**IPC-4103/570**
Nominal Dielectric Permittivity Range (Dk)	:	**6.00 to 8.99**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/580** with the following:

Specification Sheet #	:	**IPC-4103/580**
Nominal Dielectric Permittivity Range (Dk)	:	**9.00 to 11.00**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing

- Replace **IPC-4103/590** with the following:

Specification Sheet #	:	**IPC-4103/590**
Nominal Dielectric Permittivity Range (Dk)	:	**> 11.01**
Nominal Permittivity	:	**X) AABUS**
Dielectric Permittivity Tolerance	:	**1) +/-0.02 2) +/-0.04 3) +/-0.05 4) +/-0.25 5) +/- 0.50 X) AABUS**
Permittivity Test Frequency (Hz)	:	**A) 10^6 B) 10^{10} X) AABUS**
Dielectric Loss Tangent at 10^{10} Hz (Df)	:	**1) < 0.0025 2) ≥ 0.0025 X) AABUS**
Resin System	:	**A) PTFE B) Hydrocarbon C) Polyester D) Thermoplastic E) Thermosetting F) Thermoplastic/Thermoset Blend X) AABUS**
Filler	:	**1) Ceramic 2) Clay 3) No Filler X) AABUS**
Reinforcement	:	**A) Woven E-Glass B) Non-Woven E-Glass C) Random Glass D) None X) AABUS**

BONDING LAYER REQUIREMENTS (optional customer call-outs)*

Bonding Layer Requirement	Specification	Units	Test Method***	Ref. Para.
1. Bonding Layer Parameters	AABUS	AABUS	AABUS	1.2.10
2. Flammability** as laminated				
A. Average burn time, maximum	5	seconds	2.3.9	3.10.2.1
B. Individual burn time, maximum	10	seconds	2.3.10	3.10.1.1

* Requirements are part of the initial qualification testing.
** Hydrocarbon materials to be AABUS
*** See Table 3-4 for qualification testing and where a documented Manufacturers Quality System is absent for conformance testing